Scanning Magnetic Microscope Model SMM-770

Operating Guide

TRISTAN TECHNOLOGIES, Inc

San Diego, California
USA

www.tristantech.com

Operating Guide

for

Single channel HTS SQUID microscope

Model SMM-770

Option 77P, 77V, 77T, 77B, 77HR, MS-770

TRISTAN TECHNOLOGIES, Inc

San Diego, California
USA

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Revision Record		
Date	**Revision**	**Description**
May 6, 2005	Version 1.	Initial Release
May 11, 2005	Version 1.1	actual data included
May 31, 2005	Version 1.2	more data

Any questions or comments in regard to this product and other products from Tristan Technologies, please contact or see http://www.tristantech.com:

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WARRANTY

TRISTAN TECHNOLOGIES Limited Warranty

TRISTAN TECHNOLOGIES Inc. warrants this product for a period of twelve (12) months from date of original shipment to the customer. Any part found to be defective in material or workmanship during the warranty period will be repaired or replaced without charge to the owner. Prior to returning the instrument for repair, authorization must be obtained from TRISTAN TECHNOLOGIES Inc. or an authorized TRISTAN TECHNOLOGIES service agent. All repairs will be warranted for only the unexpired portion of the original warranty, plus the time between receipt of the instrument at TRISTAN TECHNOLOGIES and its return to the owner.

This warranty is limited to TRISTAN TECHNOLOGIES' products that are purchased directly from TRISTAN TECHNOLOGIES, its OEM suppliers, or its authorized sales representatives. It does not apply to damage caused by accident, misuse, fire, flood or acts of God, or from failure to properly install, operate, or maintain the product in accordance with the printed instructions provided.

> **This Warranty Is In Lieu Of Any Other Warranties, Expressed Or Implied, Including Merchantability Or Fitness For Purpose, Which Are Expressly Excluded. The Owner Agrees That TRISTAN TECHNOLOGIES' Liability With Respect To This Product Shall Be As Set Forth In This Warranty, and Incidental Or Consequential Damages Are Expressly Excluded.**

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DIRECTIVE 97/23/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment states that "*Whereas equipment subject to a pressure of* **not more than 0,5 bar** *does not pose a significant hazard due to pressure; whereas there should not therefore be any obstacle to its free movement within the Community; whereas this Directive applies to equipment subject to a maximum allowable pressure exceeding 0,5 bar*". Since the maximum allowable design pressure is less than 0.5 bar, Tristan's model **SM770** is in conformity with DIRECTIVE 97/23/EC.

1. SYSTEM OVERVIEW

The Model SMM-770 Scanning Magnetic Microscope System is a close spaced HTS SQUID magnetometer system (Figure 1-1) that has been designed and built by Tristan to detect B_z magnetic field. The main system consists of:

- Liquid nitrogen dewar with HTS SQUID Sensor
- Scanning stage
- X-y tilt stage
- Vibration Isolation table
- iMAG® SQUID control electronics[1], motion control hardware and software, data acquisition hardware and software and a computer system.
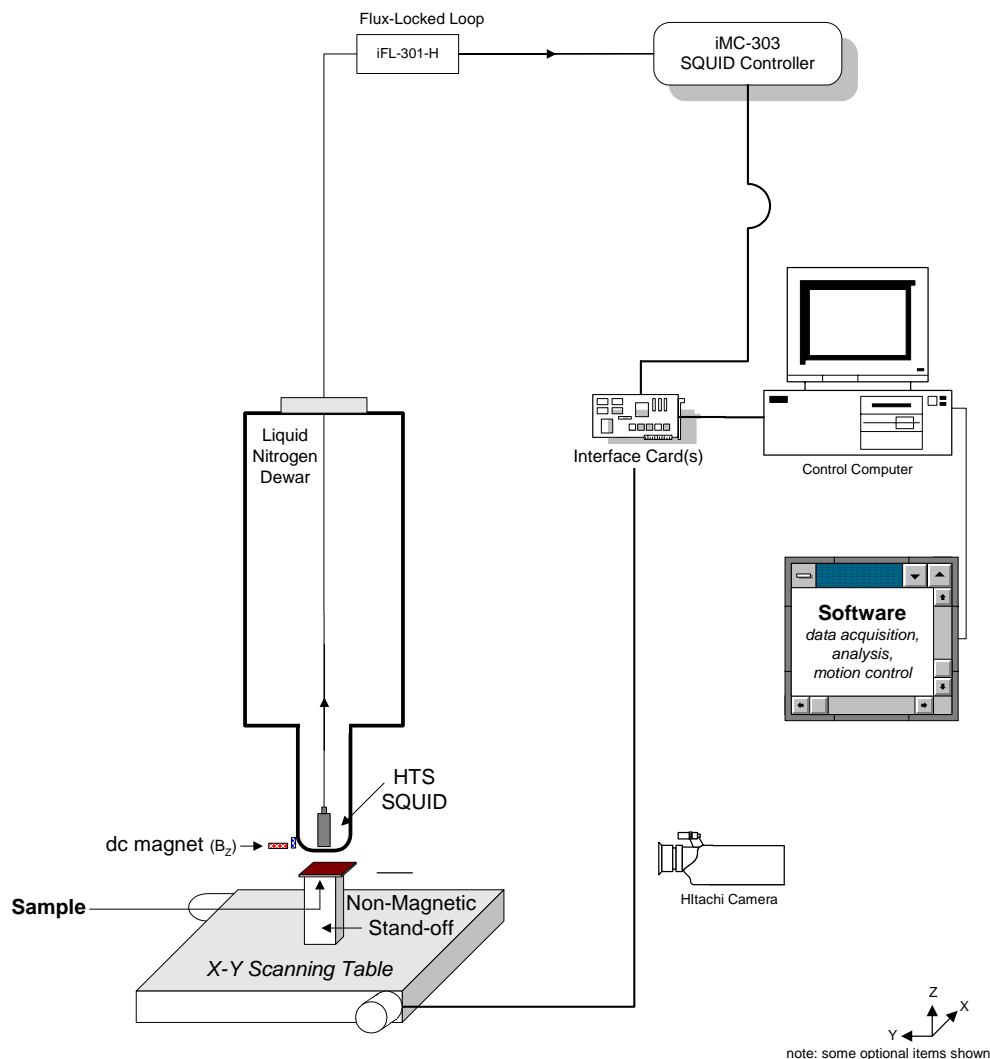
Figure 1-1:   SQUID System

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[1] iMAG® is a registered trademark of Tristan Technologies, Inc.

770 MICROSCOPE SCANNING STATION

Z

X

Y

DEWAR

FIBER OPTIC LIGHT

VIDEO MICROSCOPE

SQUID
WINDOW

SPACER PLATE
(OPTIONAL)

X-Y MICRO TILT STAGE

Z-AXIS, MANUAL

AXIS DIGITAL
READOUT

X-Y AXIS, MOTORIZED

VIBRATION TABLE TOP

ACTIVE
DAMPING
(3 UNITS)

VIBRATION
ISOLATION
AIR TABLE
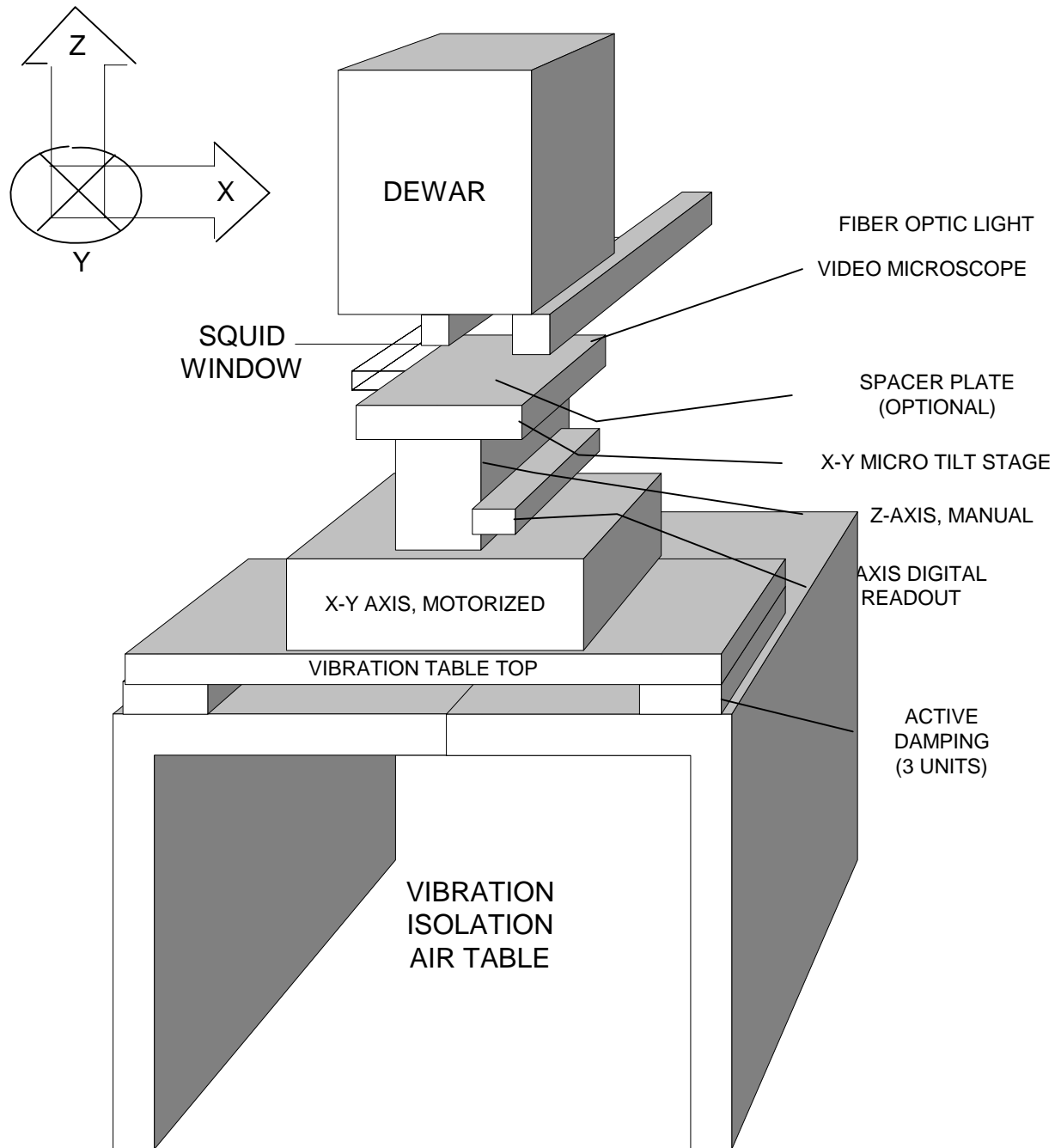
Figure 1-2:   Microscope Setup

1.1 INITIAL INSPECTION

All Tristan Technologies instruments and equipment are carefully inspected and packaged at Tristan Technologies prior to shipment. However, if a unit is received mechanically damaged, notify the carrier and the nearest Tristan Technologies representative, or the factory in San Diego, California. Keep the shipping container and packing material for the carrier and insurance inspections.

WARNING

USE CARE WHEN HANDLING THE DEWAR. THE SQUID SENSOR IS MOUNTED ON A SPECIAL MECHANISM TO ACCURATELY PLACE THE TIP CLOSE TO THE WINDOW. MISHANDLING MAY CAUSE MISALIGNMENT OF THE SQUID MOUNTING.

If the unit does not appear to be damaged but does not operate to specifications, contact the nearest Tristan Technologies representative or the Tristan Technologies factory and describe the problem in detail. Please be prepared to discuss all surrounding circumstances, including installation and connection details. After obtaining authorization from the Tristan Technologies representative, return the unit for repair along with a tag on it identifying yourself as the owner. Please enclose a letter describing the problem in as much detail as possible.

1.2 REPACKING FOR RETURN SHIPMENT

If it is necessary to return the system, you should repack the unit in its original container (if available). For this reason, it is advisable to save the original crate sent by Tristan Technologies. However, if this is not possible, use the following instructions for repackaging:

1. Wrap the unit in either bubble wrap or foam rubber

2. Cover the bottom of a sturdy container with at least 3 inches of Styrofoam pellets or shredded paper.

3. Set the unit down onto the packing material and fill the rest of the container with Styrofoam or shredded paper. The unit must be completely protected by at least 3 inches of packing material on all sides.

1.3 RETURN FROM CUSTOMERS OUTSIDE THE U.S.A.

To avoid delays in Customs clearance of equipment being returned, contact the Tristan Technologies representative in your area, or the Tristan Technologies factory in San Diego, California, for complete shipping information and necessary customs requirements. Failure to do so can result in significant delays.

1.4 SYSTEM COMPONENTS

- Dewar NLD-770   s/n 153
- Option 77P   Pneumatic vibration isolation non magnetic microscope table
- Option 77V   Active vibration cancellation

- Option 77T   Tilt tip frame
- Option 77B   Fixed field capability
- Option 77HR   12.5 micron step capability
- Option MS-770   Two layer Mu metal shield

- Electronics Rack

    BNC Adapter: National Instruments, model BNC-2090, s/n 112FBE6

    Controller iMAG®, model iMC-303, s/n 001063

    GPIB cable

    Flux-Locked loop (FLL), iFL-301-H s/n2020

    Composite fiber optic cable CC-60

    Cable SP-7 , HTS Cryogenic Cables

    (1) Special Cable: <u>Single-Ended BNC to Differential Dual BNC</u>.

    Motor drive , model MID-7602, s/n E006A6

    Motion Controller cable

- Computer control and data acquisition system and software

    Dell Precision PWS370 with dual Pentium 4 2.8 GHz CPUs and 1.00 GB RAM, model WHM, s/n 49YGZ61, service code 9309223945

    Windows XP Pro, product key J8C4W-PTCW4-X7JPR-WTBWV-XXYTB

    GPIB card, National Instruments, model PCI-GPIB, s/n 110EF26

    DAQ card, National Instruments, model PCI-6036E, s/n 10ECA27

    Motion Control card, National Instruments, model PCI-7342, s/n DF5E03

    Video card, National Instruments, model PCI-1405, s/n 111FD9C

    LabView custom software ,MagScan version 3.0

- Video monitors, 19": Dell, model DP/N-0G6566,

    s/n CN-0G6566-47804-51U-U3V2

    s/n CN-0G6566-47804-51U-U3MU

- Compressor: Jun-Air, model 3-04, s/n 582261

- Microscope & Dewar Assembly

  SQUID sensor mod HTM-0 s/n Mi 10803

  7B Fixed DC capability

- Microscope gantry:

  Dewar Vacuum gauge Dunaway DST-531

  Laser Ranger; Banner LG10A65PI

  Readout; Red Lion PAXP-1/8

  Omron DC power supply S8VS-06024A

  Tip/Tilt stage 2071-S00

  Motorized room temperature XY stage with controller consistinf of:

  - o X motorized stage, 12.5 micron step

    > Parker Daedel, model 106006BTMSD4L3C2M1E1, s/n 052316401A

    > Parker Daedel, model ZETA57-51-MO, s/n 05033000124

  - o Y motorized stage, 12.5 micron step

    > Parker Daedel, model 106008BTMSD4L3C2M1E1, s/n 052316401A

    > Parker Daedel, model ZETA57-51-MO, s/n 05033000125

  Manual room temperature Z stage, 1 micron step,   Newport 16660 / Oriel 14000

- Microscope/telescope with illuminator and high resolution video camera

  CCD camera: Hitachi, model KP-D20BU, s/n 4087307

  Camera lens: Computar

  Fiber optic light source: Dolan-Jenner, model DC-950AK, s/n 0504031224

- Passive Damping System: TMC Micro-g, model 63-531, s/n 3349301

- Active Damping System: Newport Optics Activator AD500, model NVX-1206-1,
  s/n 4076-0059

  s/n 4076-0072

  s/n 4076-0076

- Oriel micrometer 1400

- Battery for oriel micrometer, SR44, 1.5V, No 938882

- MuMetal Shield 2104-S100-4

- Accessory pack

  Dewar o-ring 166, Qty. 2

Nose piece o-ring 030, Qty 2

Nose piece screws 4-40-1/4″ SHCS, Brass

Spacer plate Screws ¼"-20 SHCS

- System Manuals

SMM-770 system manual

Dell Precision workstation 370 Quick Reference Guide

Dell Desktop Computers Product Information Guide

Dell Drivers and User Documentation E193FP LCD Monitor CD (2)

Windows XP professional SP2

Dell Precision Workstation ResourceCD

Parker Compumotor Zeta Drive Installation Guide

Daedal Linear and Rotary Positioners Operating Manual (2)

Zeta Drive User Guide

Parker Optical L/H Switch Cable Pigtail Ended Cable drawing (2)

Parker Quality Assurance Data Sheet (2)

Newport Isostation vibration isolated workstation

Newport Active vibration Damping system

DC950 Illuminator Operation Manual

Duniway digital gauge Instruction Manual

Hammond Enclosures RCHS-Series Assembly Instructions

NI-DAQ 7 DAQ Quick Start Guide

NI-488.2 CD, NI Montion control CD, NI-IMAQ 3.1 Getting Started CD

NI GPIB Installation guide

MID-7604/7602 Power Drive User Guide (2)

DAQ BNC-2090 User Manual

IMAQ 1405 User Manual

MID-7604/7602 Power Drive Front Panel DIP Switch Settings Sheet

NI Registration Cards (4), Global Service Support Booklet (4)

Jun-Air compressor

OMRON Sensor

Banner L-GAGE Laser sensor

Red Lion Analog input panel meter

Imag Manuals (2)

2. CRYOGENIC SYSTEM

The cryogenic system includes a fiberglass liquid nitrogen dewar (Figure 2-1). The sensor-window gap is pre-set at the factory and does not need adjustment.
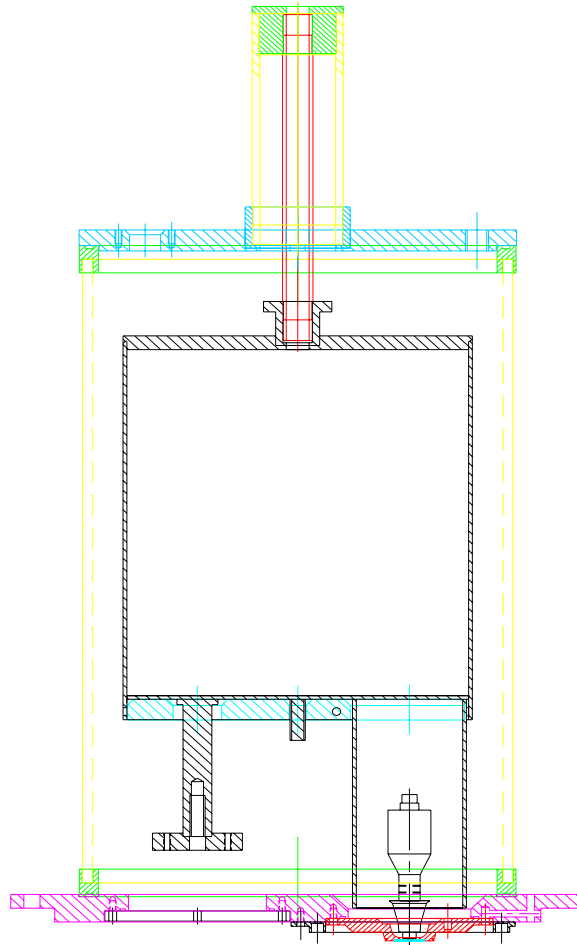
Figure 2-1:   Cryogenic Dewar

2.1 LIQUID NITROGEN MAINTENANCE

The system nitrogen level can be measured with a small fiberglass stick (supplied)

2.2 NORMAL INSTALLATION AND OPERATION

2.2.1 PROBE INSTALLATION (WARM DEWAR)

- Inspect dewar and verify internal cavity is free from ice, moisture, or other contaminants. CONTAMINANTS COULD RESULT IN INCORRECT MEASUREMENTS OR PROBE DAMAGE!

2.2.2 NITROGEN TRANSFER

- Verify Nitrogen level in Microscope dewar.

- Open transfer port at top of dewar.

- Begin Nitrogen transfer observing all standard cryogenic handling and safety procedures.

- Observe transfer levels. * *Note: Dewar capacity is 2.29 liters*.

- Plug transfer port after allowing sufficient vent time.

- Verify all connectors at top of probe are free from moisture.

2.3 SAFETY PRECAUTIONS FOR HANDLING CRYOGENIC LIQUIDS

The potential hazards of handling liquid nitrogen stem mainly from the following properties:

WARNING

1. **THE LIQUID IS <u>EXTREMELY</u> COLD**

2. **THE ULTRA-LOW TEMPERATURE OF LIQUID NITROGEN CAN CONDENSE AND SOLIDIFY AIR.**

3. **VERY SMALL AMOUNTS OF LIQUID NITROGEN ARE CONVERTED INTO LARGE VOLUMES OF GAS.**

4. **NITROGEN IS NOT LIFE SUPPORTING.**

2.3.1 EXTREME COLD-- COVER EYES AND EXPOSED SKIN

Accidental contact of liquid nitrogen or the cold gas that results from its rapid evaporation may cause a freezing injury similar to a burn. Protect your eyes and cover the skin where the possibility of contact exists. Eye protection should always be worn when transferring liquid nitrogen.

2.3.2 KEEP AIR AND OTHER GASES AWAY FROM LIQUID NITROGEN

The low temperature of liquid nitrogen, vacuum pumped liquid nitrogen, or cold gaseous nitrogen can solidify another gas. Solidified gasses and liquid, particularly solidified air, can plug pressure-relief passages and foul relief valves. Plugged passages are hazardous because of the continual need to vent the nitrogen gas that evolves as the liquid continuously evaporates. Therefore, always store and handle liquid nitrogen under positive

pressure and in closed systems to prevent the infiltration and solidification of air or other gases. Do not permit condensed air on transfer tubes to run down into the container opening.

2.3.3 KEEP EXTERIOR SURFACES CLEAN TO PREVENT COMBUSTION

Atmospheric air will condense on exposed nitrogen-cooled piping. Nitrogen, having a lower boiling point than oxygen, will evaporate first from condensed air, leaving an oxygen-enriched liquid that may drip or flow to nearby surfaces. Areas and surfaces upon which oxygen-enriched liquid can form, or come in contact with, must be cleaned to oxygen-clean standards to prevent possible ignition of grease, oil, or other combustible substances. Leak-testing solutions should be selected carefully to avoid mixtures that can leave a residue that is combustible. When combustible type foam insulations are used, they should be carefully applied to reduce the possibility of exposure to oxygen-enriched liquid that could, upon impact, cause explosive burning of the foam.

2.3.4 Pressure-Relief Devices Must Be Adequately Sized.

Liquid nitrogen evaporates very rapidly when heat is introduced or when liquid nitrogen is first transferred into warm or partially cooled equipment. Even minor deterioration of the vacuum in the nitrogen container can result in significant evaporation. Pressure relief devices for liquid nitrogen equipment must, therefore, be of adequate capacity to release nitrogen vapor resulting from such heat inputs, and thus, prevent hazard due to excessive pressure. This system has been designed to safely vent the evolving nitrogen gas in the event of any reasonable failure mode. If transfer lines can be closed off at both ends so that a cryogenic liquid or the related cold gas can become trapped between the closed ends, a pressure-relief device must be provided in that line to prevent excessive pressure build-up.

> ## *WARNING*
>
> **DO NOT MAKE ANY MODIFICATIONS TO THIS SYSTEM WHICH MIGHT AFFECT ITS ABILITY TO VENT NITROGEN GAS IN THE EVENT OF AN EMERGENCY, SUCH AS LOSS OF VACUUM IN THE DEWAR VACUUM SPACE**

2.3.5 KEEP EQUIPMENT AREA WELL VENTILATED

Although nitrogen is nontoxic, it can cause asphyxiation in a confined area without adequate ventilation. Any atmosphere which does not contain enough oxygen for breathing can cause dizziness, unconsciousness, or even death. Nitrogen, being colorless, odorless, and tasteless cannot be detected by the human senses and will be inhaled normally as if it were air. Without adequate ventilation, the expanding nitrogen can displace air and result in an atmosphere that is not life supporting. The cloudy vapor that appears when liquid nitrogen is exposed to the air is condensed moisture, not the gas itself. The issuing nitrogen gas is invisible. Liquid containers should be stored in large, well-ventilated areas.

If a person becomes groggy or loses consciousness when working around nitrogen, get them to a well-ventilated area immediately. If breathing has stopped, apply artificial respiration. If a person loses consciousness, summon a physician immediately.

2.4 GENERAL INFORMATION

- Use caution when handling delicate fiber-optic cables. Do not bend smaller than a 10 cm radius.

- Do not fill with liquid nitrogen unless dewar vacuum is < 50 microns.

- Transfer nitrogen with fill tube inserted to the dewar bottom.

- Do not touch sapphire window at any time ever!

3. SENSORS AND CONTROL ELECTRONICS

3.1 WIRING DIAGRAM
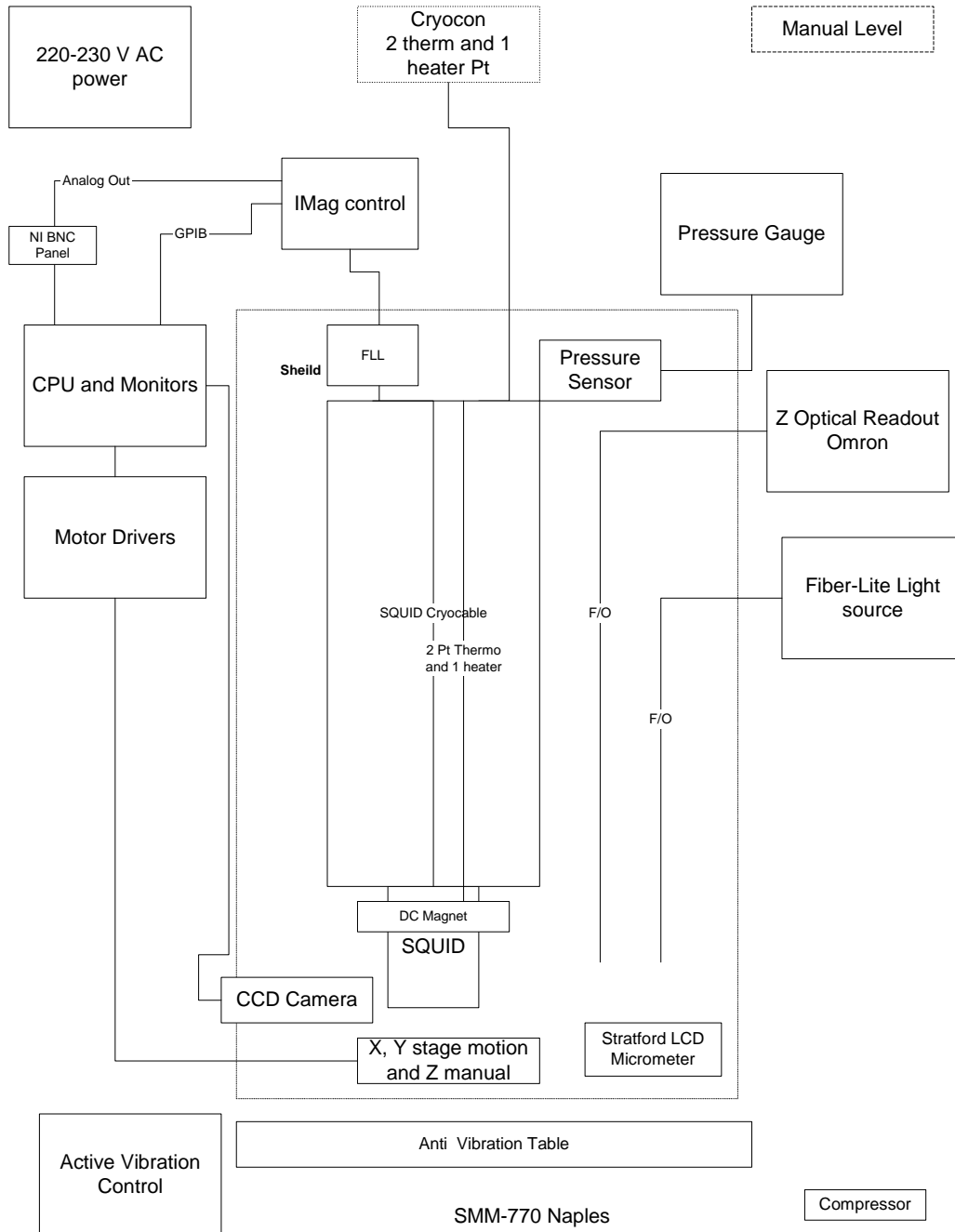
Figure 3-1   Overview of SMM770 wiring diagram
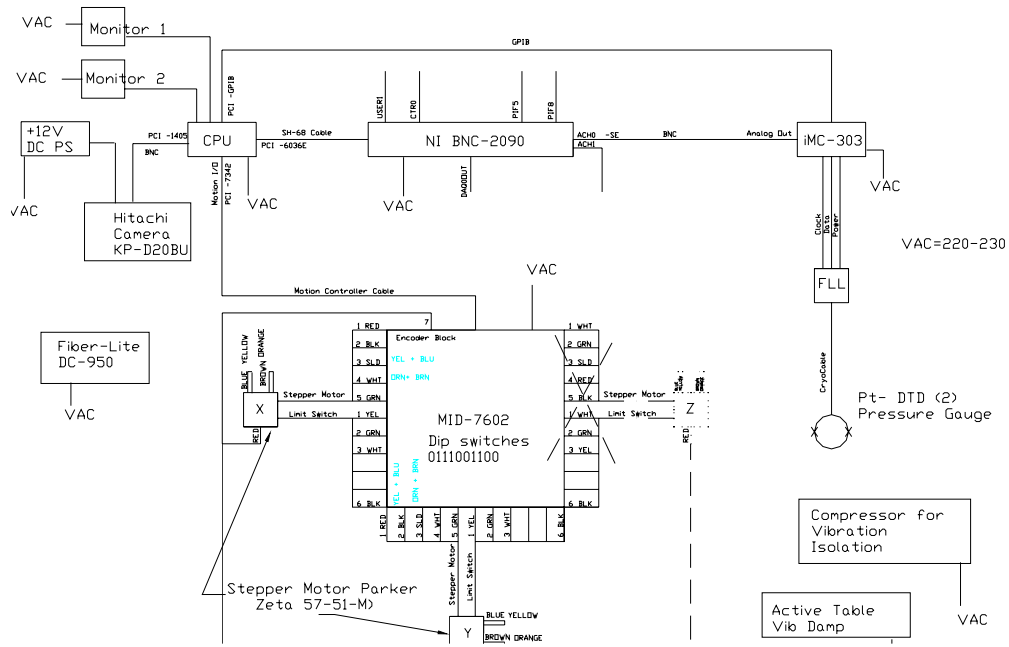
Figure 3-2   SMM770 detailed wiring diagram

3.2 SENSOR INITIAL PERFORMANCE TEST

3.3 MEASURED PARAMETERS AND FACTORY TEST DATA

The following parameters were measured at Tristan prior to shipment. Performance data is the result of testing done at Tristan.

3.3.1 SQUID sensors

The HTM-0 SQUID sensor was initially tested in a HTS superconducting shield to eliminate all external environmental noise contributions. Testing was done using Tristan iMAG® 300 SQUID electronics. The flux transfer function (nT/ϕ_o) and noise (pT/√Hz) was determined. The test results of the supplied SQUID sensors are shown in Figure 3-3 as a function of frequency, and are listed along with sensitivity (informational purposes only).
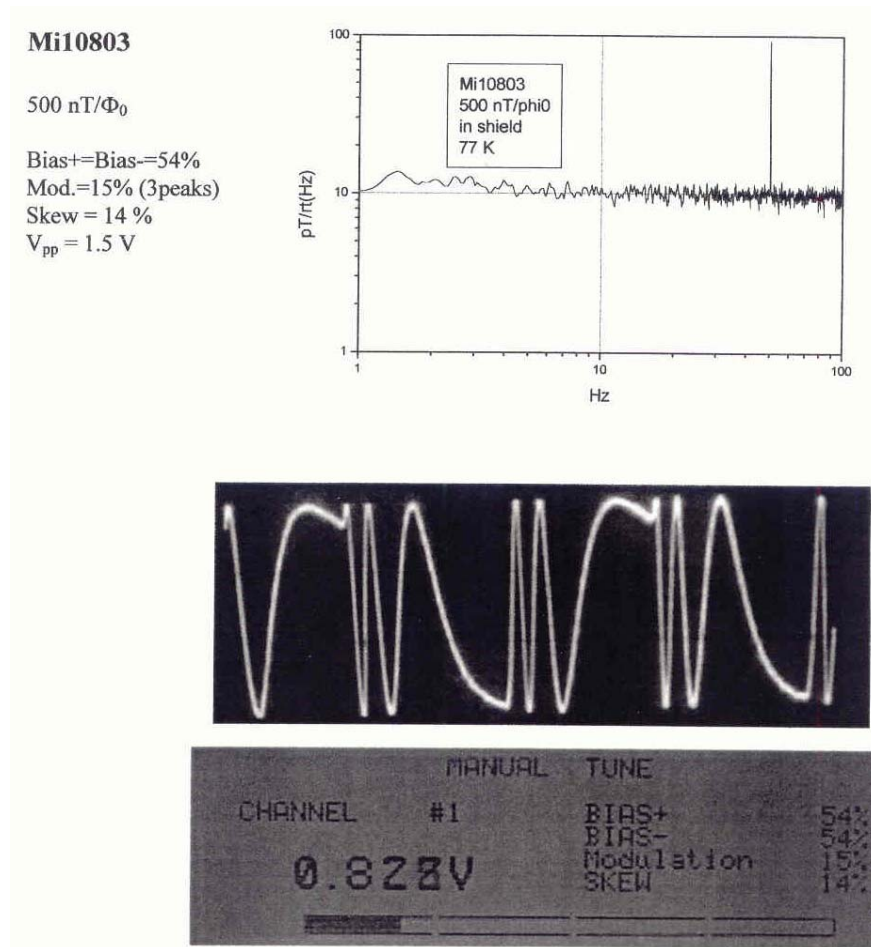
Figure 3-3:   Manufacturer-supplied noise spectrum and tune specs

3.3.2 Measurements in a non-superconducting shield

Additional measurements were made at Tristan in a non-superconducting mu-metal shield. These tests determine the bandwidth and voltage transfer function for the device. Operation at various gains and ranges are verified using the customer's electronics. Testing is done using Hewlett-Packard (34401 A DMM, 35665A dynamic signal analyzer) and other appropriate test equipment.

Because of the local environmental noise (even inside a mu-metal shield), these measurements show different noise levels than the results shown in Figure 3-3. It should be noted that HTS SQUID sensors typically show a 10 - 30% variation from device to device. Table 3-2 and Table 3-2 summarize the main system's parameters and SQUID performance using a Tristan Technologies, Inc. iMC-303 iMAG® SQUID Controller.

Table 1   System Parameters

IFL-301-H	S/N 2020
SQUID	Mi10803
Channel	1
Gain	X100
Slew	Normal
Heat Time (1k R)	2 sec
Cool Time	99 sec
Triangle Amplitude	1.65 V_{p-p}
Bias%	35
Bias%	35
Mod%	12
Skew	18

Table 3-2:   SQUID performance tested with iMAG®

Gain Slew	X100 Normal	x100 Slow	X50 Normal	Units
V/Φ_o	0.95		0.95	
Noise @5kHz	9.15			pT/√Hz
Bandwidth	22			kHz
Loop Locked	yes	yes	yes	

Note – gains 1-50 are done with one feedback resistor and gains 100-500 are done with a different feedback resistor. The Gain X100 and X50 have the same analog gain so that will have to be manually accounted for when measuring data not through the software.

3.3.3 System Noise

The following spectra were taken of the complete SMM 770 system.
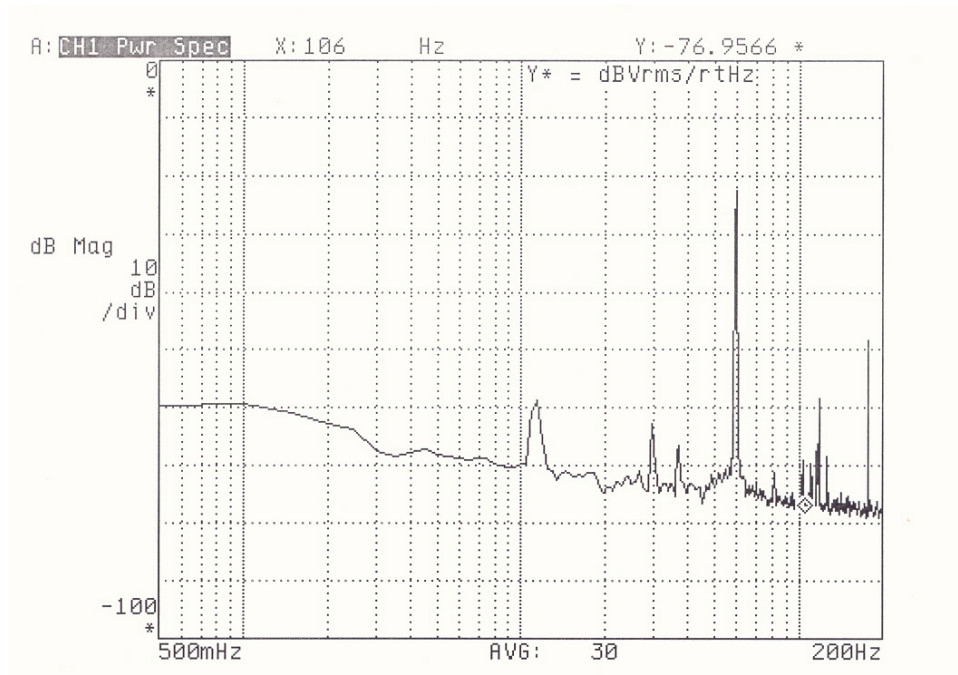
Figure 3-4   SQUID noise spectrum at (0-200Hz), 81.8 Kelvin, gain=x100
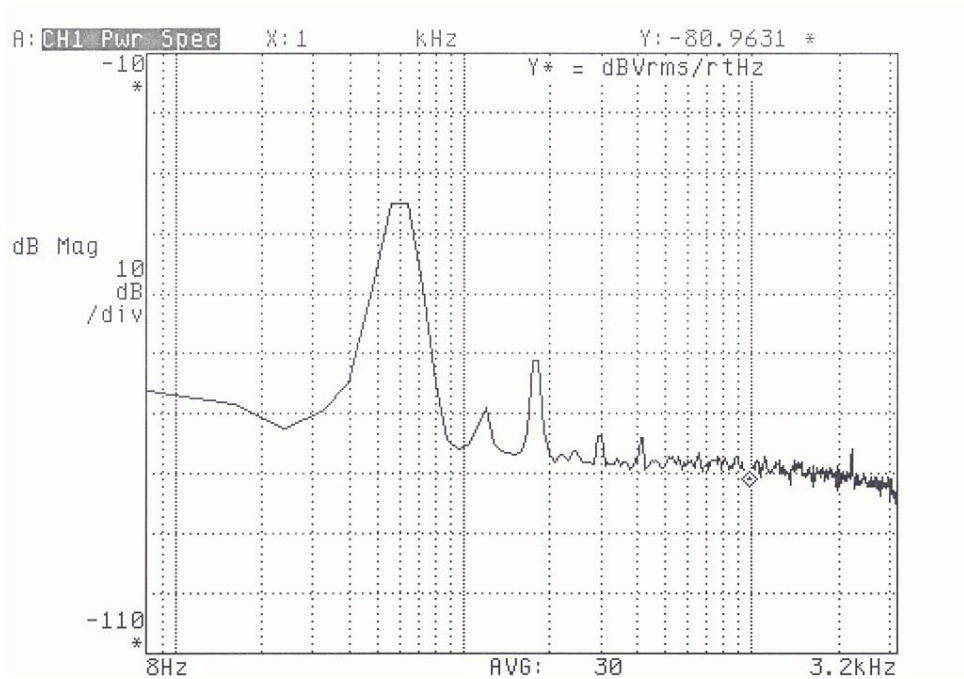
Figure 3-5   SQUID noise spectrum at (0-3.2 kHz), 81.8 Kelvin, gain=x100

Figure 3-6   SQUID noise spectrum at (0-12.8 kHz), 81.8 Kelvin, gain=x100

3.4 SENSOR CALIBRATION

The SQUID microscope sensor position is calibrated to determine a number of parameters. Using a combination of parallel wires at various liftoff values, the SQUID-to-window spacing is determined. The SQUID sensitivity is determined and the system resolution is calculated. The following charts and graphs show the data for this unit.

The system calibration for a typical SQUID is calibrated as follows:

Table 3-3:   Calibration Parameters for SMM-770

Close Wire Spacing	Wide Wire Spacing	SQUID to Wire Lift-off
0.003" (76 µm)	0.009" (229 µm)	0.0016" (400 µm)

3.4.1 Lift-off: SQUID – to- Source spacing

Determination SQUID–to–Source spacing requires comparison horizontal scans of parallel wire loops carrying current in opposite directions at various heights. Theoretical values may be calculated from Appendix 6.1.3 (Field Above a Straight Wire) and assuming infinite length with height d. By changing d to r = $(d^2 + x^2)^{1/2}$ for lateral displacement x, and defining the polar angle $\theta = \tan^{-1}(x/d)$, the vertical field varies as $\sin\theta * B_r$. Note that the magnetic field components of each wire pass constructively interfere, and thus the widely spaced wire loop produces greater field at close lift-off distances.
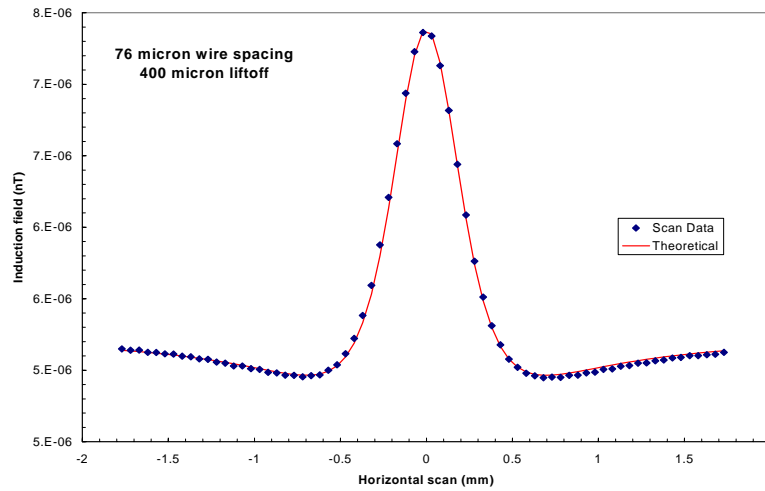
Figure 3-7:   Horizontal Scan of parallel wires 0.003" apart.

The above theoretical line is derived from a best fit to the gap between the SQUID and the wire source. This result is verified by successive horizontal scans at increasing liftoffs, and a pair of vertical scans of two sets of parallel wires. The vertical scan plots illustrate the position of the SQUID probe tip and the gap to the Sapphire window.
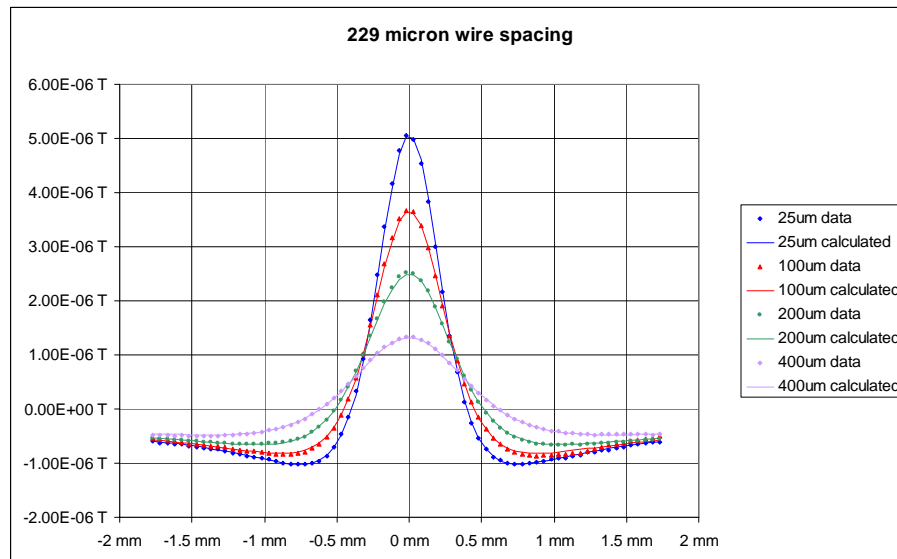
Figure 3-8:   Horizontal scans at increasing liftoffs to parallel wires 0.009" apart.

229 micron wire separation
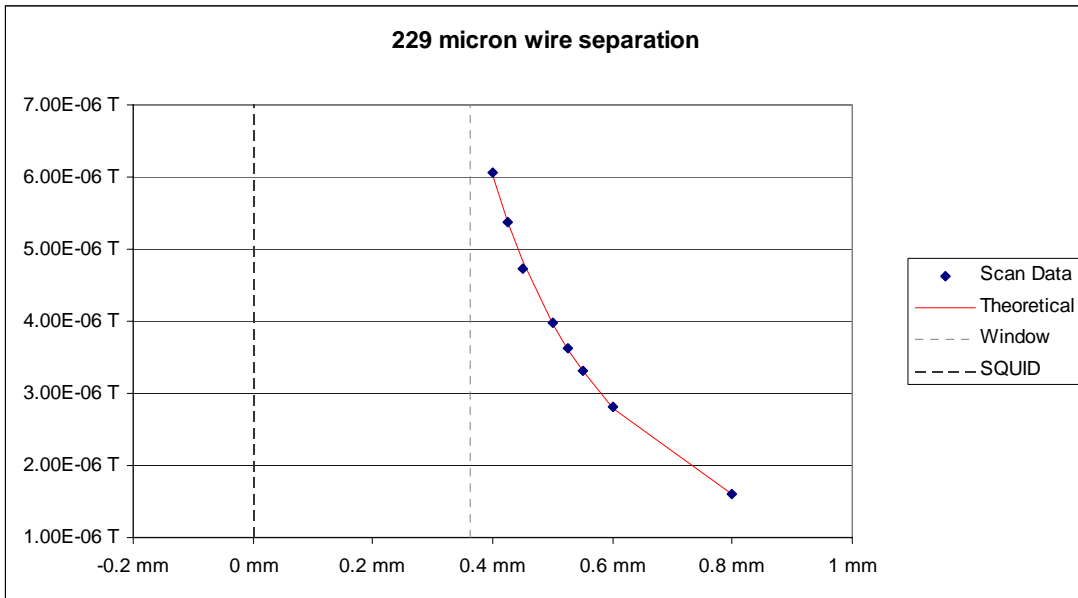
Figure 3-9:   Vertical Scan of parallel wires 0.009" apart

76 micron wire separation
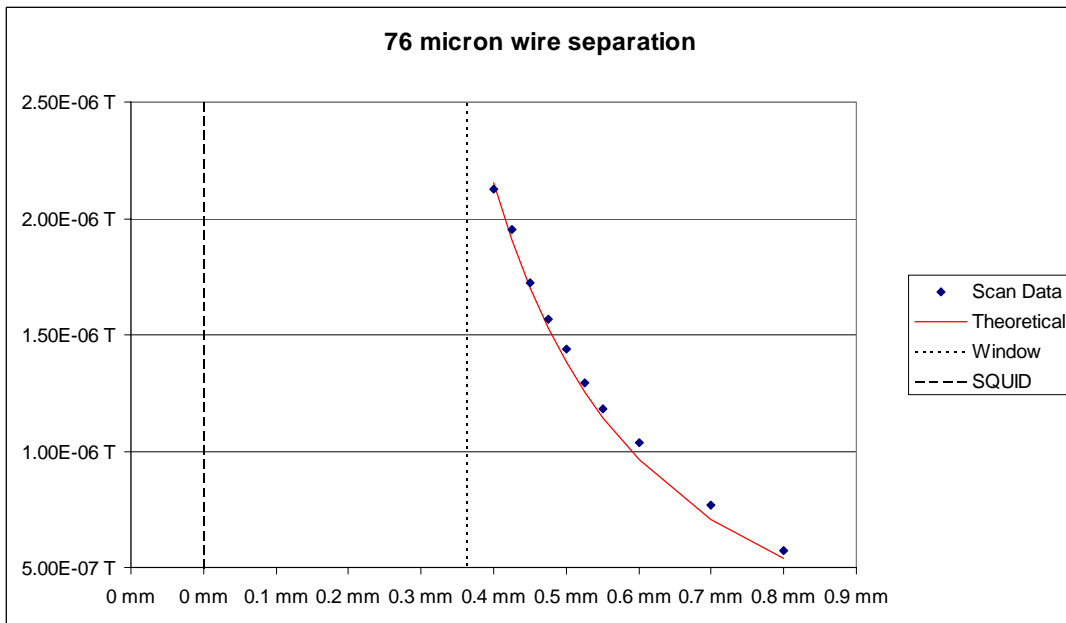
Figure 3-10:   Vertical scan of parallel wires 0.003" apart

3.4.2 Spatial resolution

Resolution is defined as the smallest detectable change in position of a single magnetic source. This can be calculated by comparison of the maximum observed spatial magnetic field gradient to the system noise level across the measurement bandwidth of interest. However, this is more easily understood visually by illustrating the accuracy at which the center of a single magnetic source can be located. Figure 3-11 shows the peak region of a horizontal scan across parallel wires spaced 76 microns apart. Each data point is spaced 50

microns apart, and it is evident from inspection that the center of the source is between the two central data points. Therefore, the system spatial resolution is better than 50 microns.
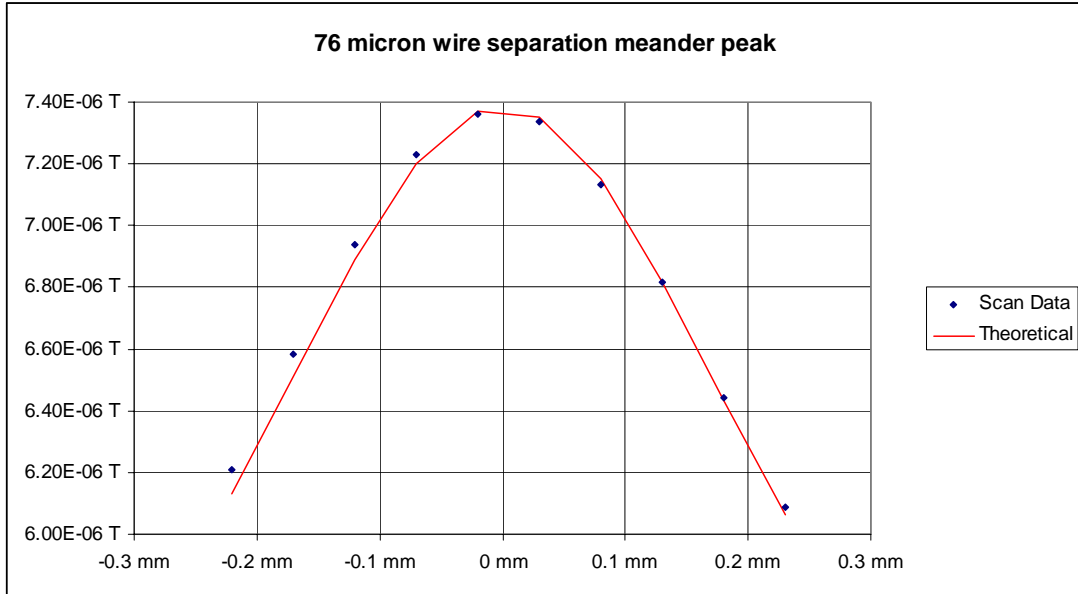
Figure 3-11:   Central peak of a horizontal scan across 76 micron separation meander coil

3.4.3 **Example data**

The first plot is the entire subject: a US Dollar bill. The outputs are at resolution of 10 micron step size of the middle three letters in the word "STATES" on the front above the bust of Washington.

Figure 3-12:   US Dollar bill
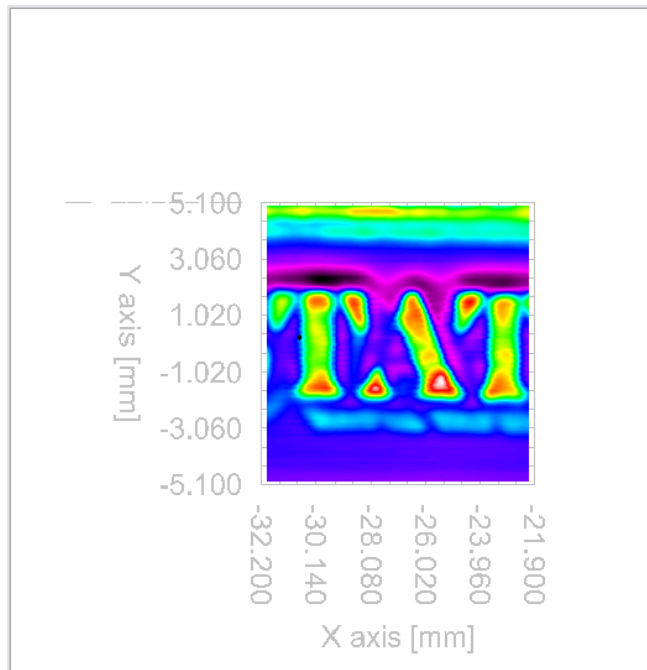
Figure 3-13:   Image showing what a small amount of processing can accomplish
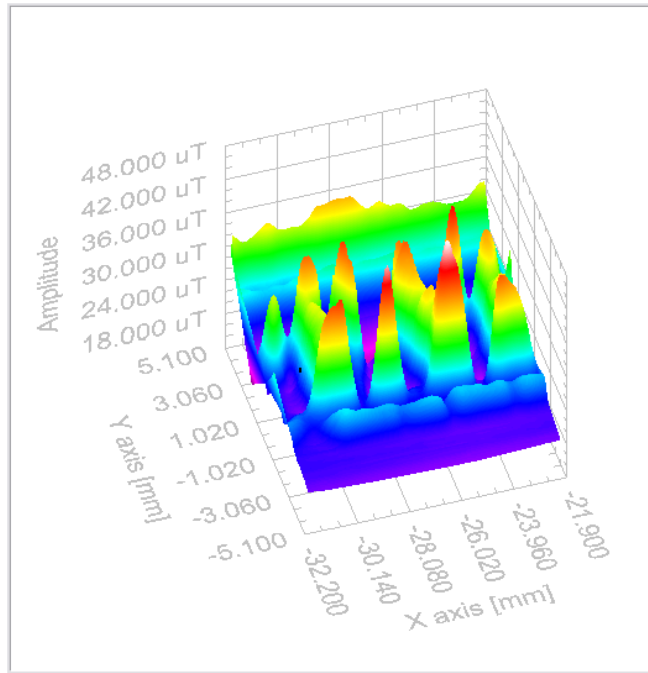
Figure 3-14**::**   The following output of data is a 3D post processing of the image shown in Figure 3-13.

4. SYSTEM SOFTWARE

4.1 START

Ensure that the iMAG iMC-303 unit and the Motor Driver MID-7602 unit are powered on. Click the "Mag Scan" icon on the desktop. This will start the magnetic scanning application. The user will be presented with a dialog box, asking the user to select an initialization file. The selected initialization file controls a variety of system settings. These files are located under `c:\MagScan\Configuration\*.ini`. It is possible for the user to manually edit these files, but Tristan recommends caution when doing so. Tristan strongly recommends that the user do **not** edit the `Default.ini` file, but rather make copies of it and edit those. All `*.ini` files are presented in the dialog box for user selection. Additionally, there is a `Current.ini` file, which contains the settings of the last time the software was run.
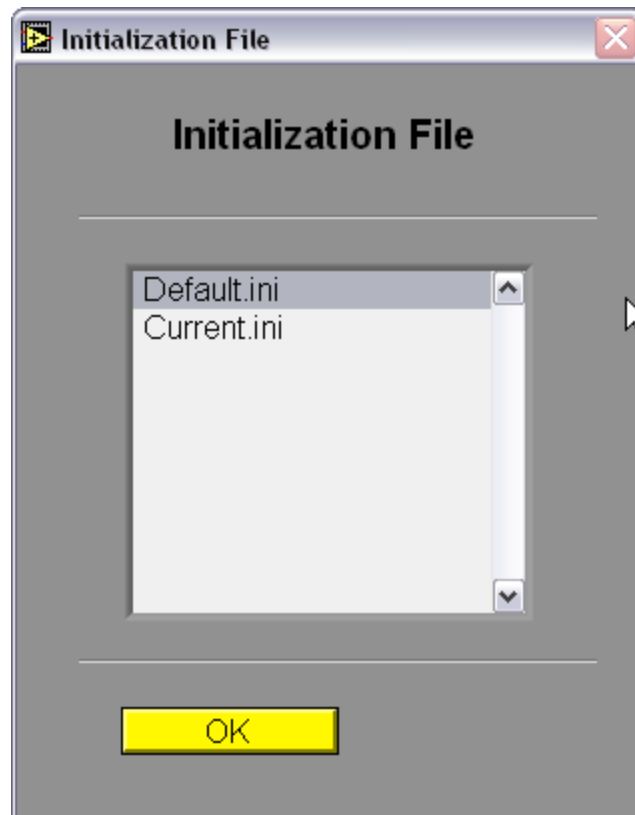
Figure 4-1: Selection of Initialization file

Typically, the user will select the `Default.ini` file, and proceed by pressing the **OK** button. The user will then see a progress bar indicating the configuration of the iMAG unit. Note that the iMAG unit must have its GPIB address = 15, which can be set from the front panel. After the iMAG unit is configured, the user will then see a progress bar indicating configuration and homing of the sample stage.

> ## *CAUTION*
>
> The user must ensure that the stage is clear of obstacles throughout the entire working region (154 mm x 154 mm) before homing starts. Improperly placed samples could cause permanent damage to the sample and/or dewar. The Tristan warranty does not cover resulting damage

Homing typically takes about 60 seconds. After this is completed, the user has access to the main screen of the software, shown below:
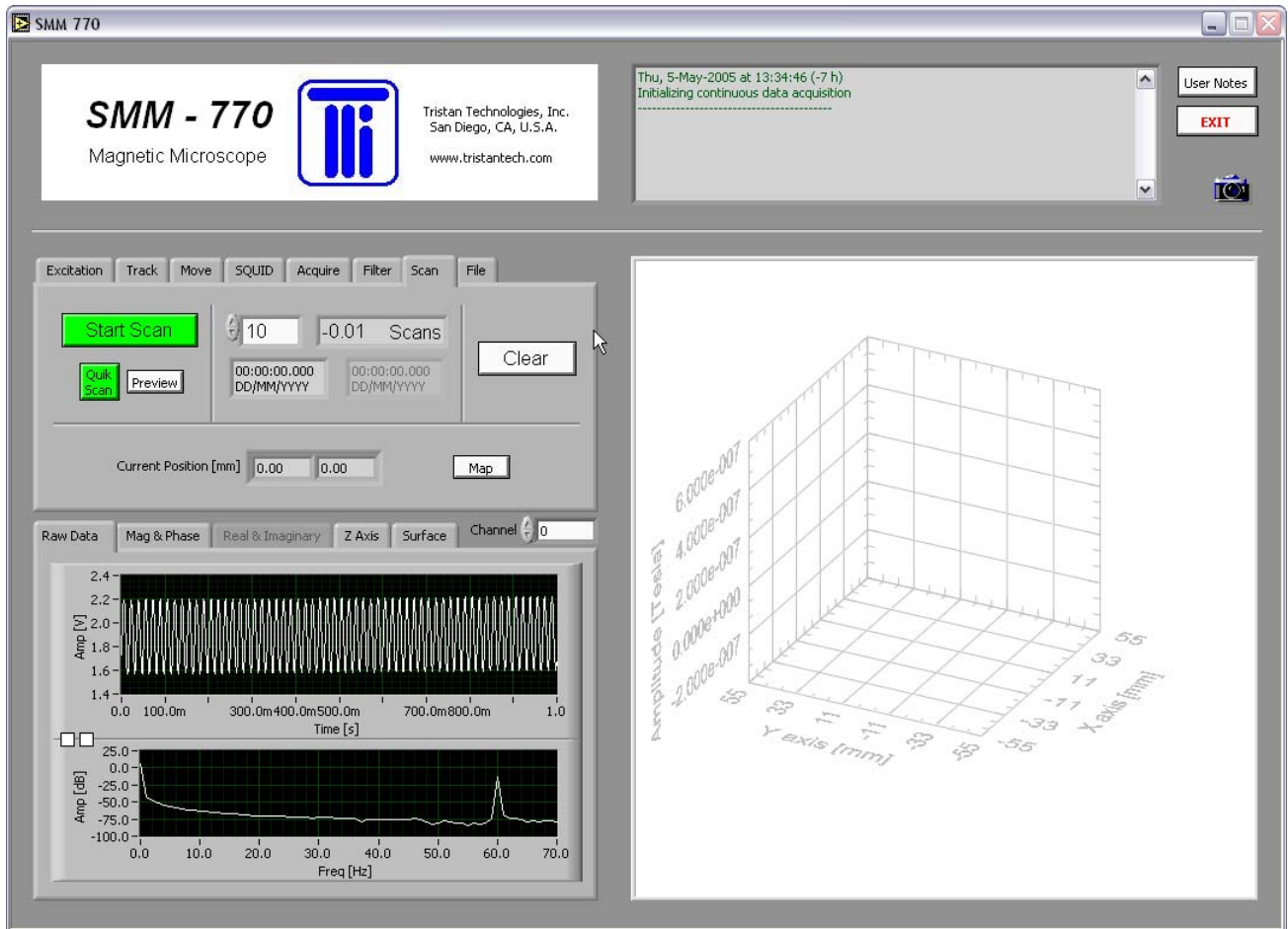
Figure 4-2:   Main panel after system start

In the upper right corner, a text box shows system messages. These messages are automatically logged to a text file under `c:\MagScan\System_Log\<YYYYMMM>\<date>_<time>.log`. These are simple ASCII files, and are named based on the current date and time. The user can insert comments into these files using the **User Notes** button.

The left side of the main panel shows two sets of tabs. The upper tab set controls the acquisition of data, and the lower one controls the display of the results.

Pressing <control>-H will pop-up a help window for any item that the mouse cursor is over. This help window provides a description of what each control and indicator does.

In general, user interface items that are colored white are controls that the user can adjust. User interface items that are colored gray are indicators. User interface items that are grayed-out have been disabled.

4.2 EXCITATION

The *Excitation* tab controls the application of a signal to an excitation coil or sample. This option is disabled for this SMM-770 delivery. Assorted controls related to excitation, such as phase shift and its real and imaginary components, are disabled throughout the user interface.

4.3 TRACK CONSTRUCTION

The *Track* tab controls the movement of the sample stage.
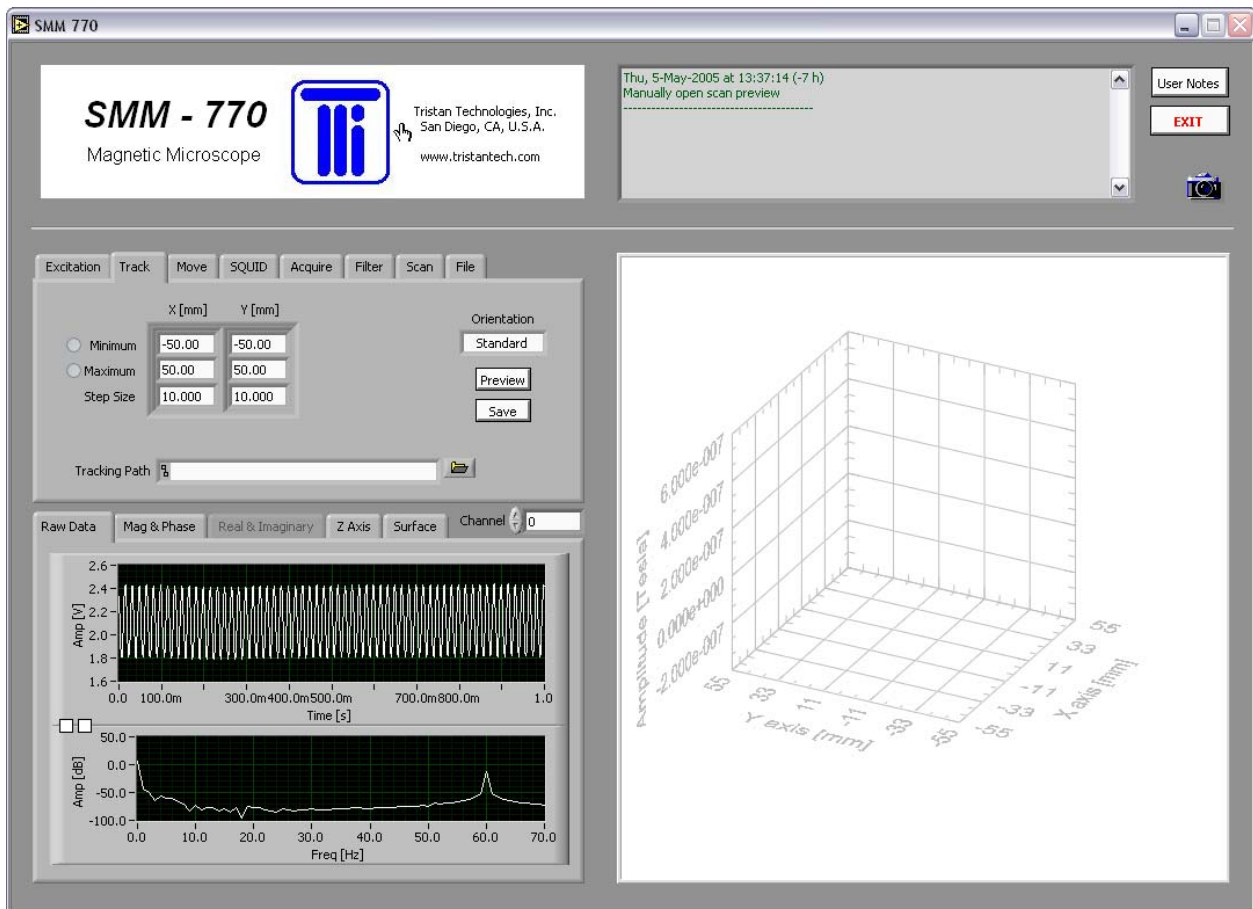
Figure 4-3:   Track parameters

The parameters in the table specify a serpentine track over which to move the stage by discrete points. The stage will move to each of these points, stop, wait, collect a SQUID measurement, and then proceed on to the next point. The speed at which the stage moves is set in the `*.ini` file. The resulting track can be previewed by pressing the **Preview** button.
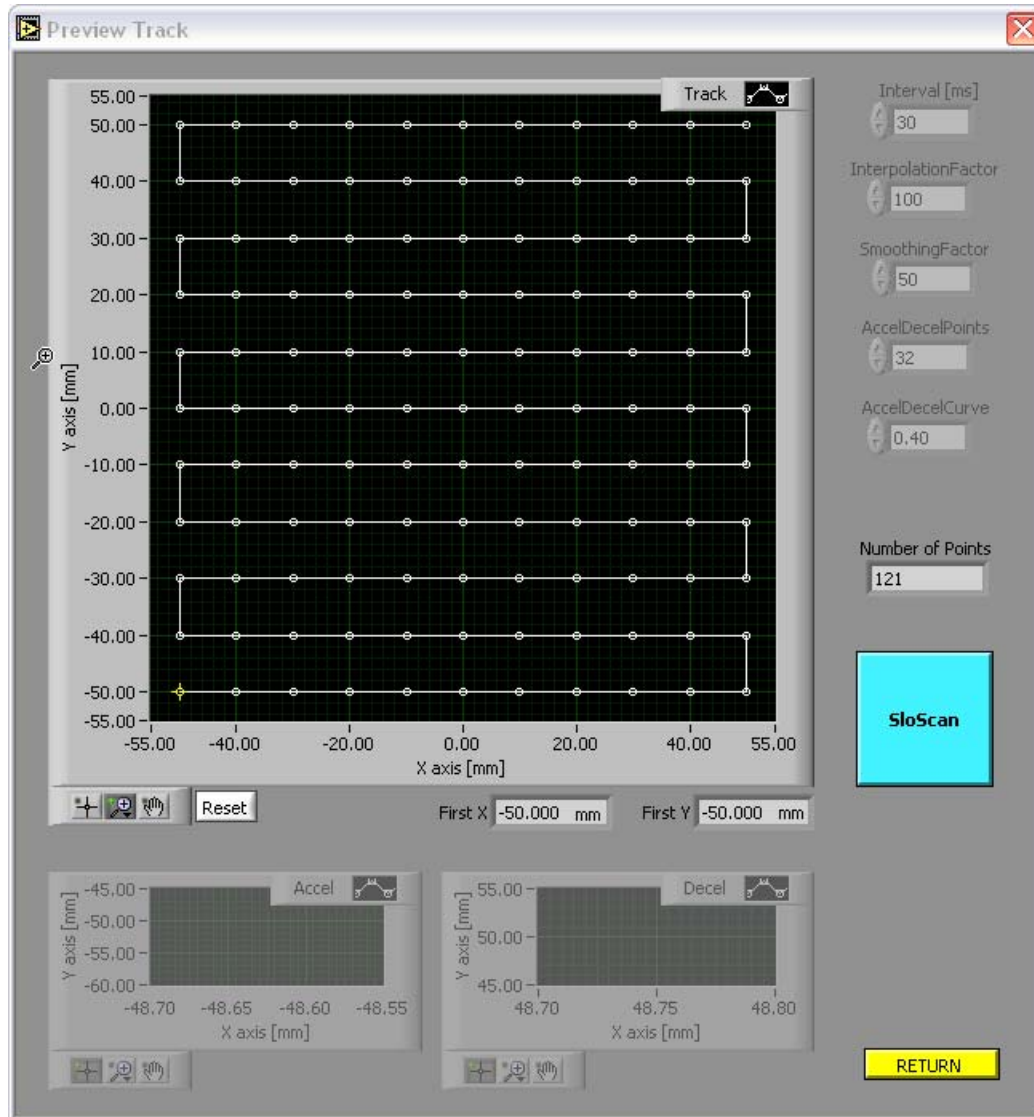
Figure 4-4:   Preview of track to be used for discrete scanning.

Collecting data in this discrete manner can be time-consuming. Alternatively, the user can perform a "Quik-Scan" (discussed below) whereby the stage is moved continuously while data is collected at uncontrolled points along the track; this is useful for a quick sample survey to identify regions of interest for more precise study by discrete scanning. The continuous track can be displayed by pressing the button on the right from **SloScan** to **QuikScan**. Because of the nature of the hardware, the full set of coordinates over which to continuously move the stage must be uploaded to the stage motion controller. Acceleration, deceleration, and interpolated points must be constructed from the defined track, with care taken to avoid the memory and speed limitations of the hardware. This construction and limitation-checking is automated. If the QuikScan parameters are improperly set, an error message will be clearly displayed and the graph grayed out. The user will be offered suggestions as to how to change the parameters to create a valid QuikScan track.
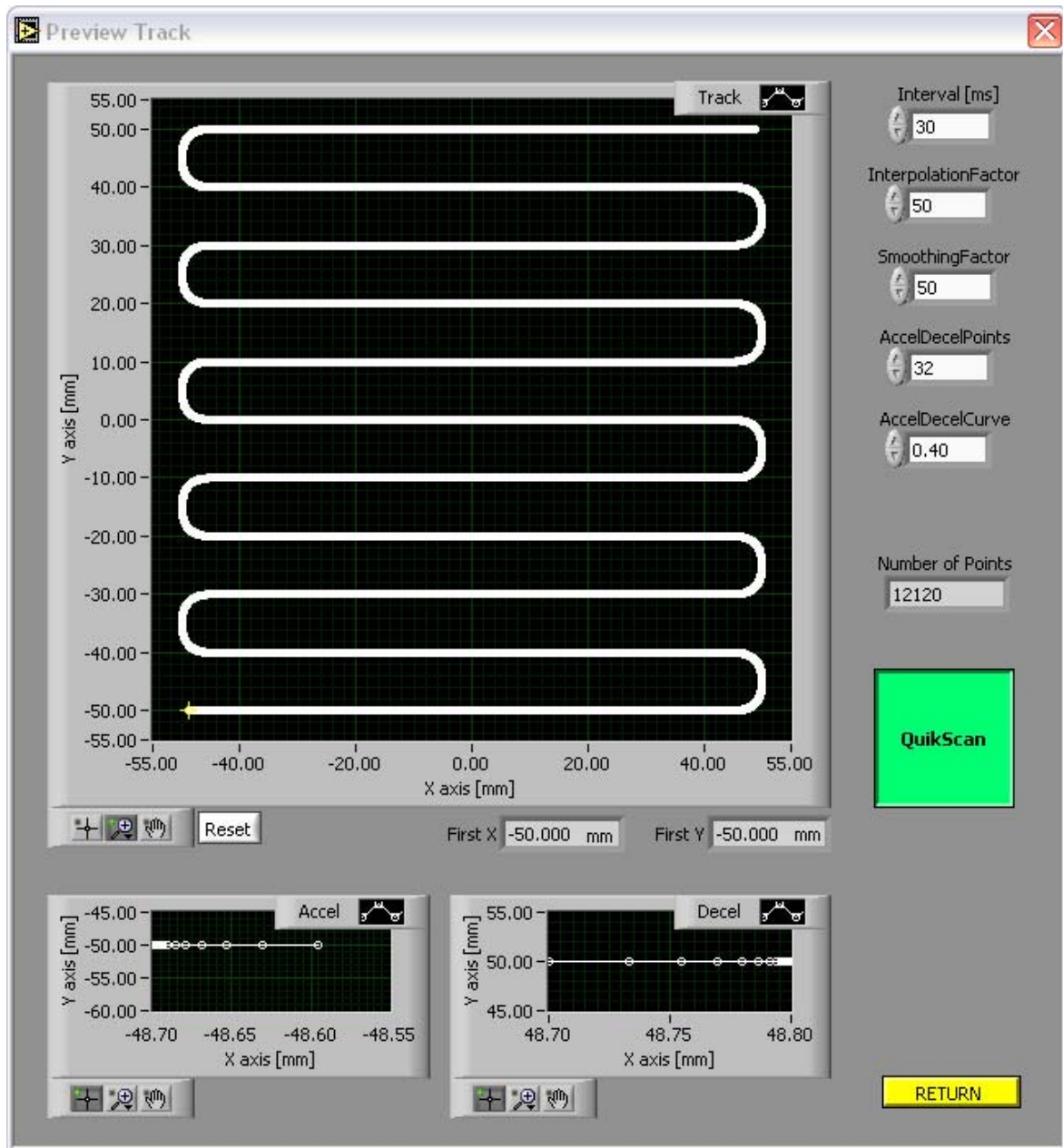
Figure 4-5:   Preview of QuikScan (continuous) track

4.4 MOVE MANUALLY

The *Move* tab manually controls the stage. This is useful for moving the stage to a position where it is easier to change samples.
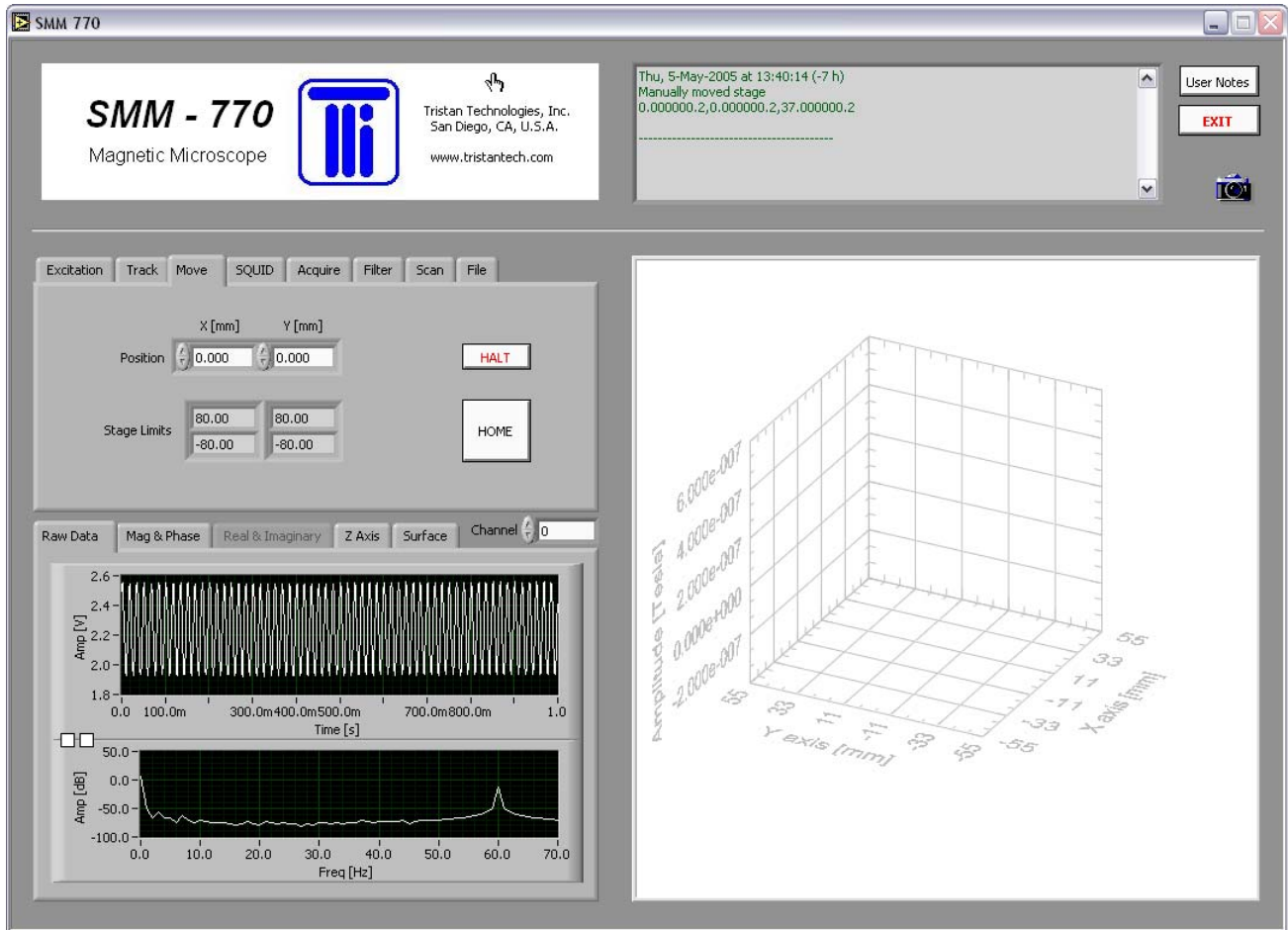
Figure 4-6: Manual control of the sample stage

> ## CAUTION
>
> The user must ensure that the stage is clear of obstacles throughout the entire working region (154 mm x 154 mm) before homing starts. Improperly placed samples could cause permanent damage to the sample and/or dewar. The Tristan warranty does not cover resulting damage.

The **HALT** button will immediately terminate movement. The **HOME** button will force the stage to home; this is theoretically unnecessary, but this utility is provided in the event of a hardware error.

4.5 SQUID PARAMETERS

The *SQUID* tab controls the iMAG settings. Tristan strongly recommends making adjustments to the iMAG by using these controls rather than the physical front panel of the instrument. Changes made from the physical front panel may not be registered in the software, and thus the data displays and files would be inaccurate. This is of special concern with the gain setting.

The data output of the iMAG can be viewed in the *Raw Data* tab. This is especially useful during a manual tune of the iMAG.
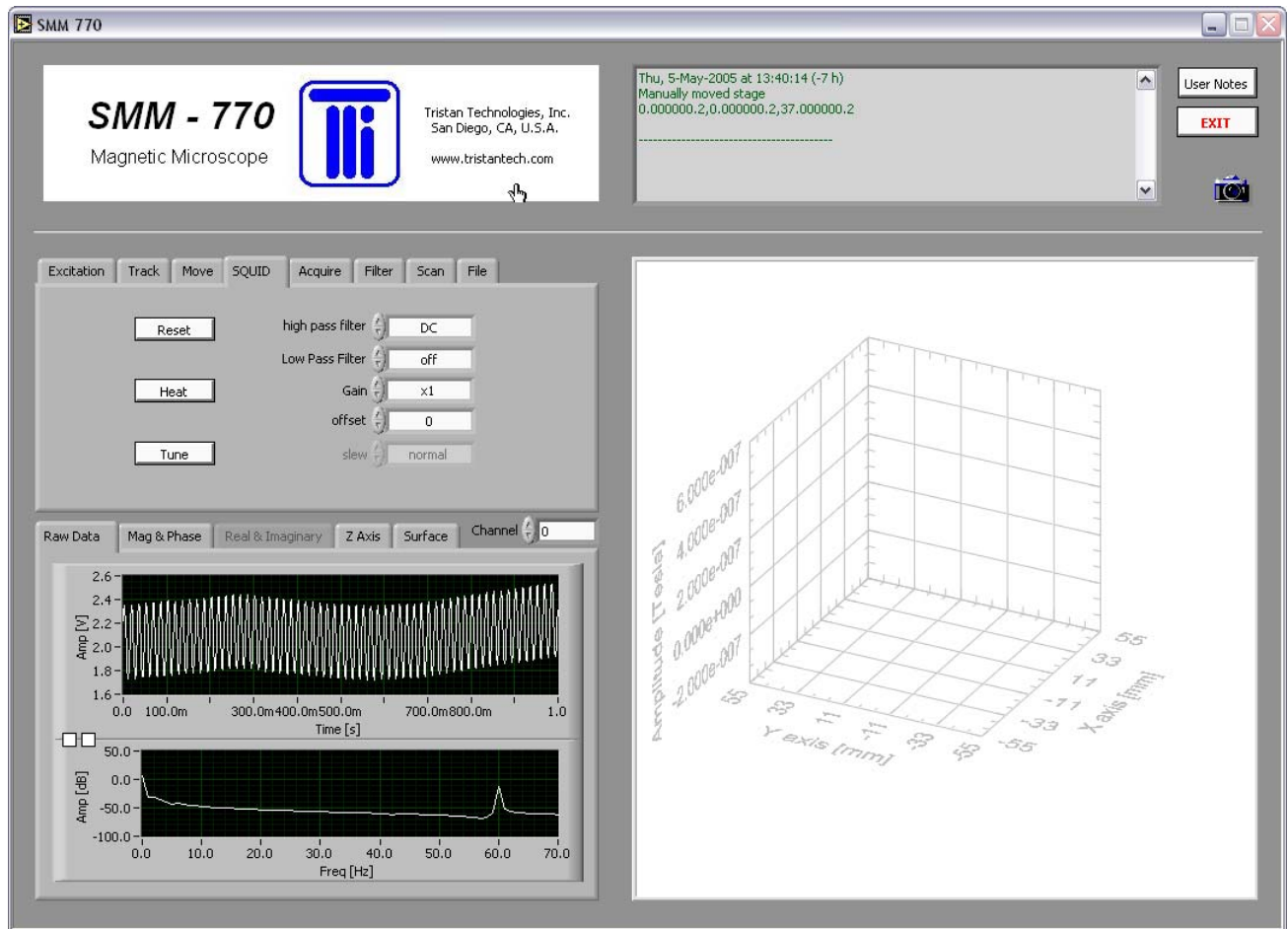
Figure 4-7:   iMAG SQUID parameters

If the Tune procedure takes longer than 45 seconds, you may see a pop-up window indicating that there is a problem with iMAG communications. This message can be ignored. It is due to the fact that the iMAG does not support GPIB communications during an auto-tune procedure.

4.6 ACQUISITION PARAMETERS

The *Acquire* tab controls the data acquisition parameters. The Sample Rate can be adjusted from 10 Hz to 10 kHz. The Settle Time defines the period of time to wait after the stage has moved to a discrete position and before collection of a block of data. The Measure Time defines the duration of a block of data to collect. The resulting block of data is processed to calculate DC and AC components that provide a measure of the magnetic field strength at the particular sample location.
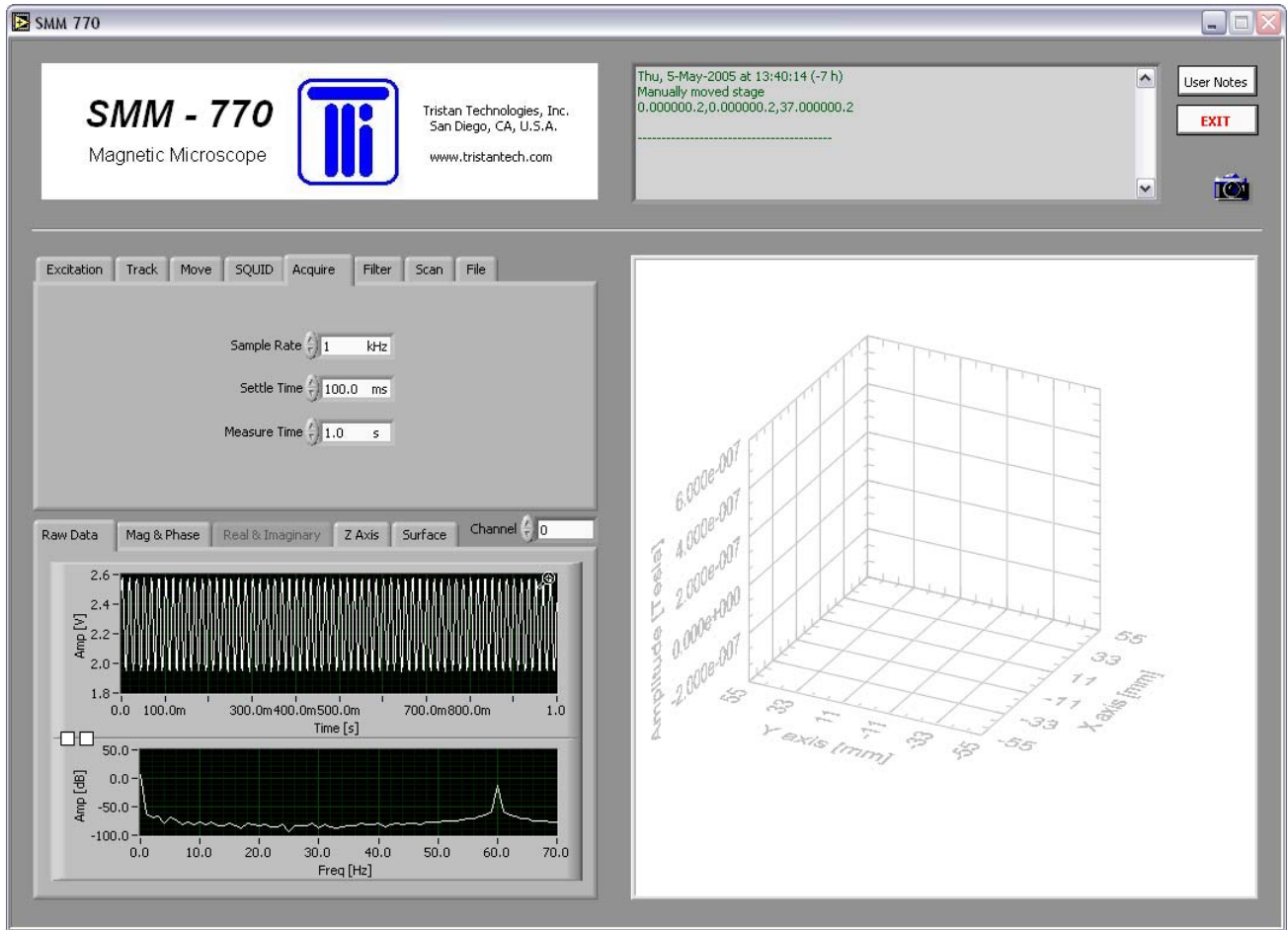
Figure 4-8:   Data acquisition parameters

4.7 FILTER PARAMETERS

The *Filter* tab controls the software filtering of raw SQUID data. This is not to be confused with the hardware filtering of raw SQUID data that can be selected using the the iMAG HiPass and LoPass filters.
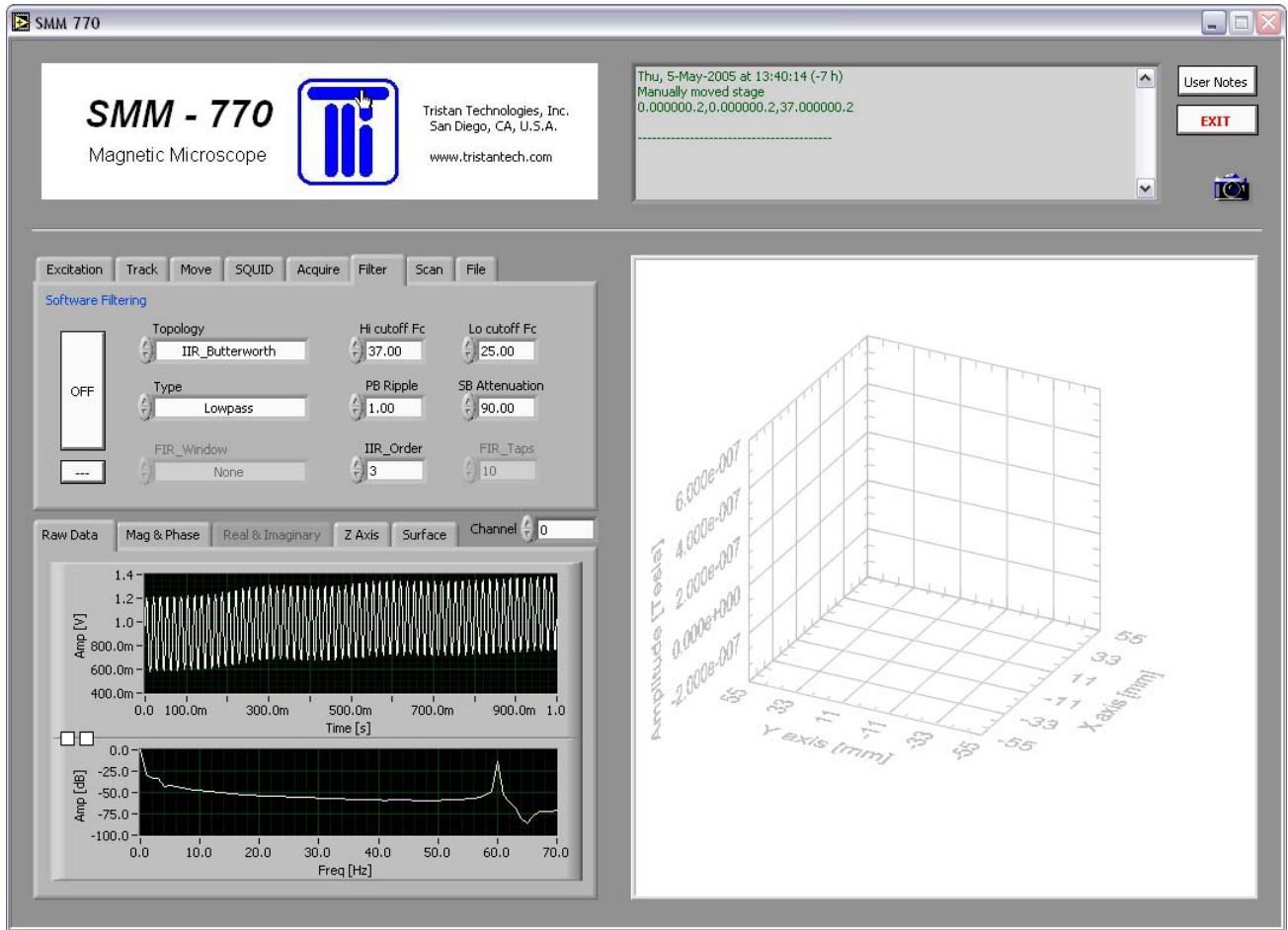
Figure 4-9:   Filter parameters

In general, these filter settings are only useful for minimizing the Mains noise seen under the *Raw Data* tab. They will not have much affect on the calculation of DC and AC components.

4.8 SCAN CONTROLS

The *Scan* tab controls collection of magnetic field data from a sample.
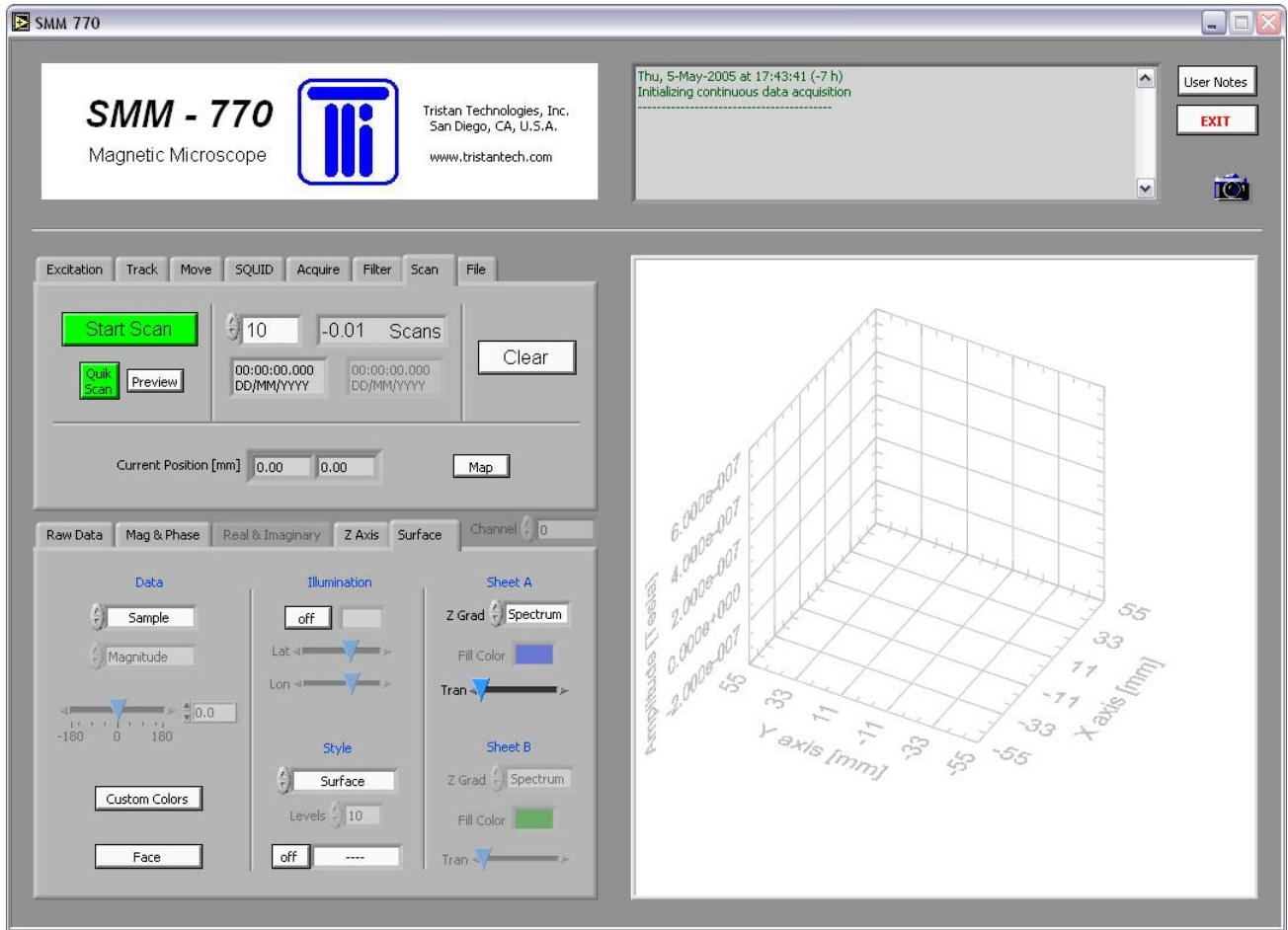
Figure 4-10:   Scan controls

The **Start Scan** button will initiate discrete scanning using the track defined under the *Track* tab. This scanning can be stopped by pressing the button again. The progress of the scanning can be viewed by using the **Map** button. This button shows the progress of the scanning.
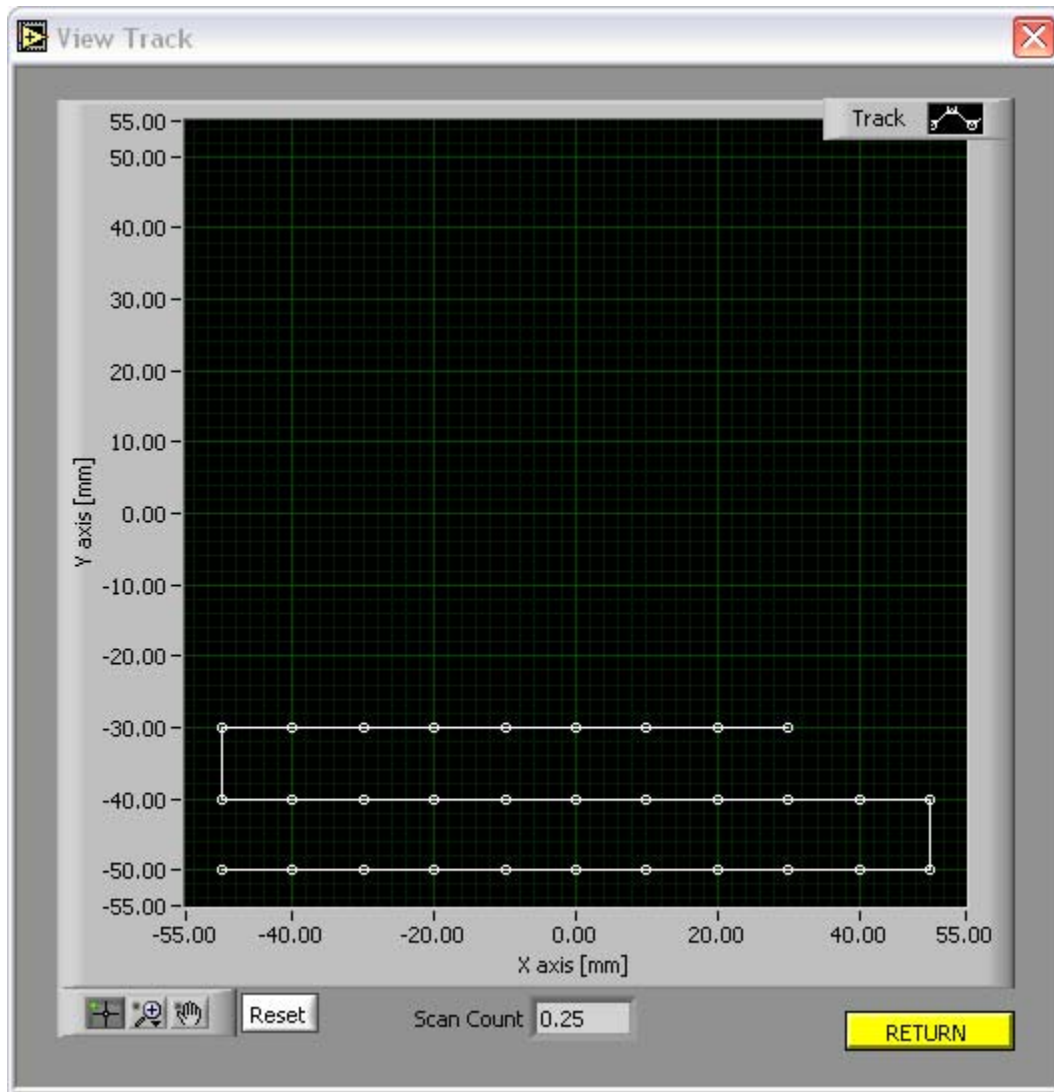
Figure 4-11:   View of scan track

After the track has completed, the track count will decrement, and another track performed, until the track count reaches zero. Data at each track point is averaged. If the track count is set to -1, the track is repeated endlessly.

Pressing the **QuikScan** button will perform a continuous scan of the sample approximately along the defined track. This will be performed only once.

As scanning proceeds, the data will be plotted as a stripchart under the *Mag & Phase* tab, and plotted in the 3D graph on the right, as shown below:
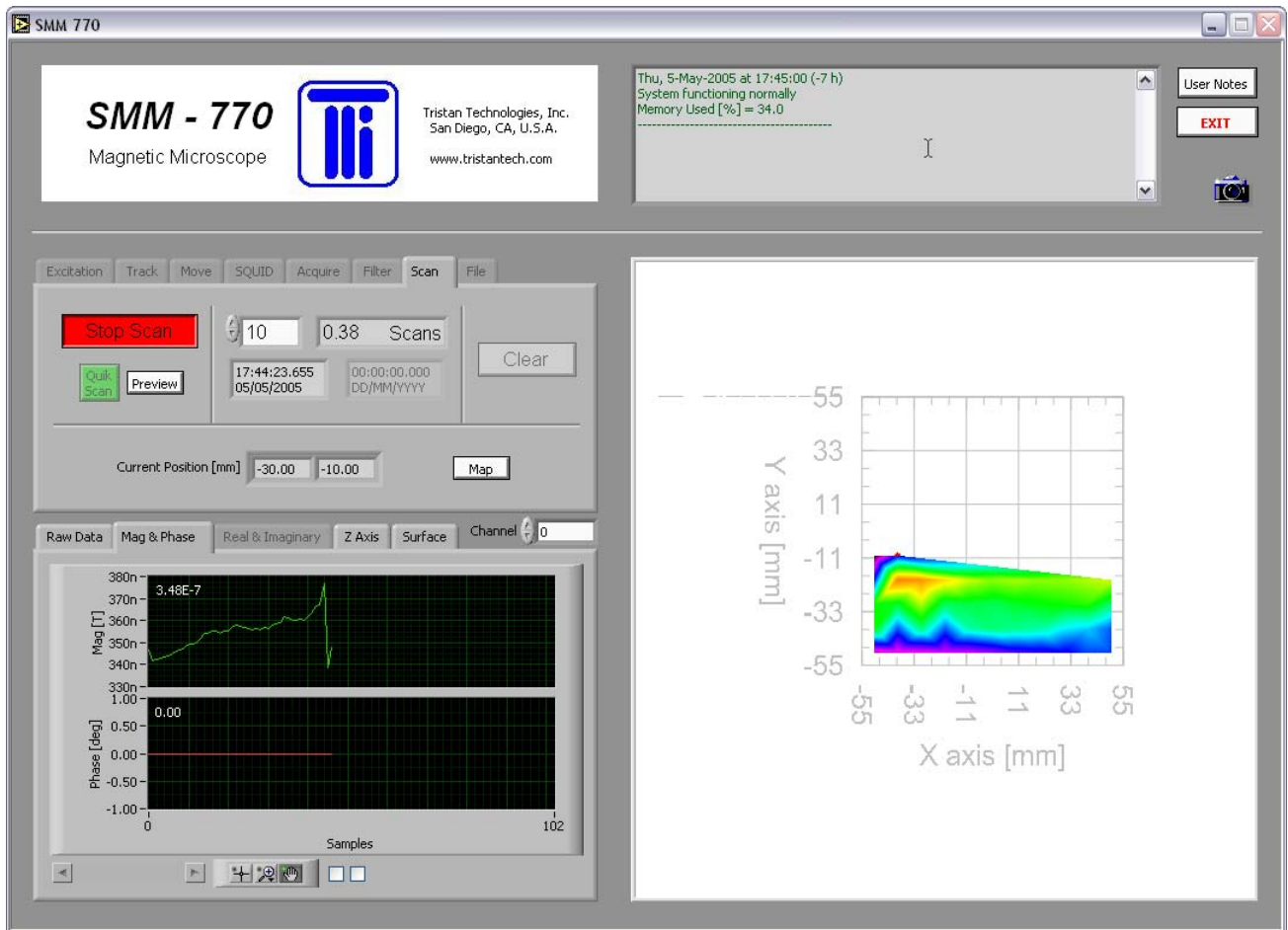
Figure 4-12:   Generation of stripchart and 3D graph

The stripchart can be paused, panned, and zoomed using the palette controls. The 3D graph can be rotated by <control>-rightclick and dragging the mouse across the graph, panned by <shift>-rightclick, and zoomed by <alt>-rightclick. The current location of the scan stage is indicated by a red dot.

Settings under the *Surface* tab allow the user to add various features such as contour lines, a cursor, or illumination control, as shown in the figures below:
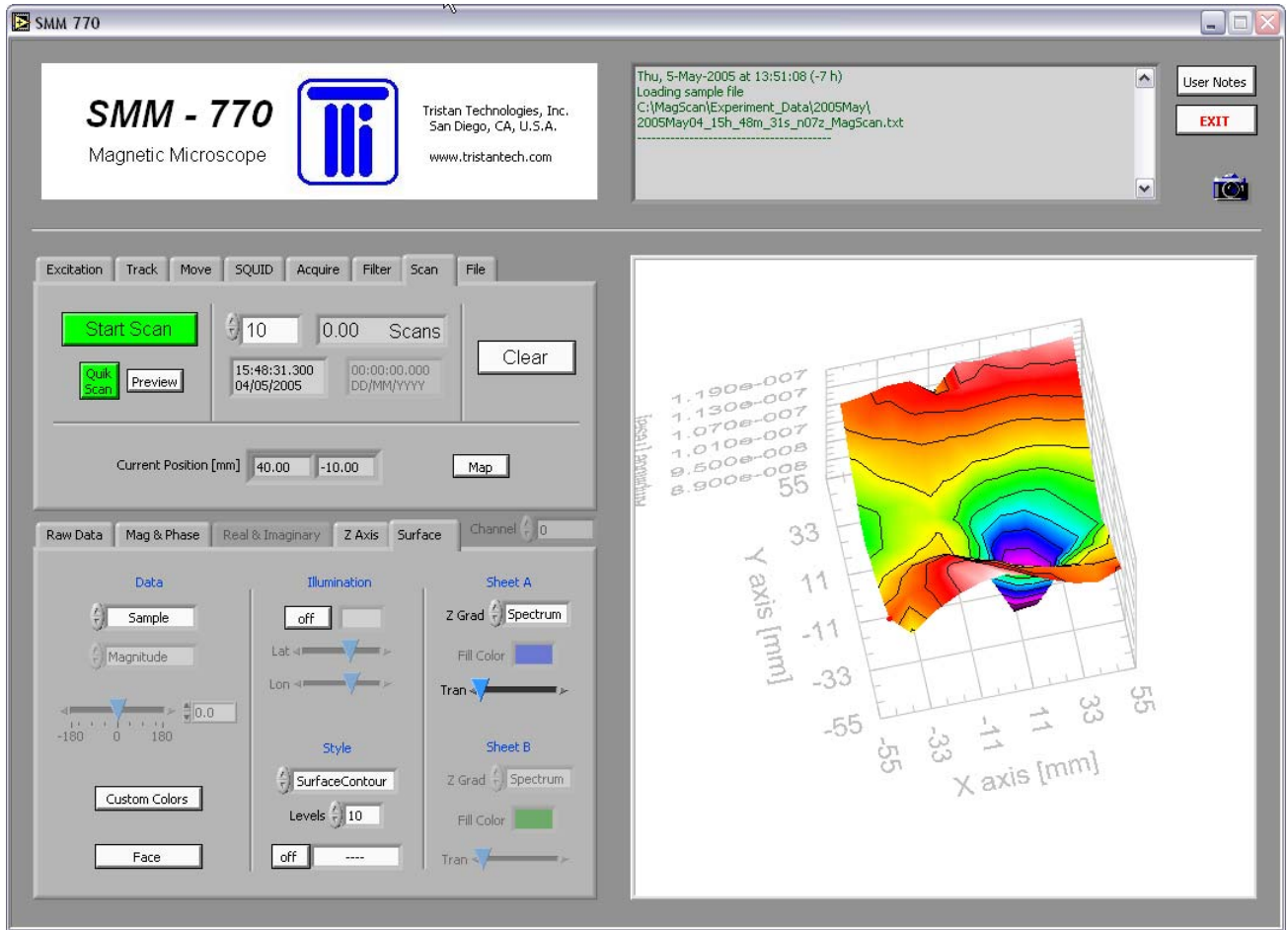
Figure 4-13:   Contour lines in the 3D plot
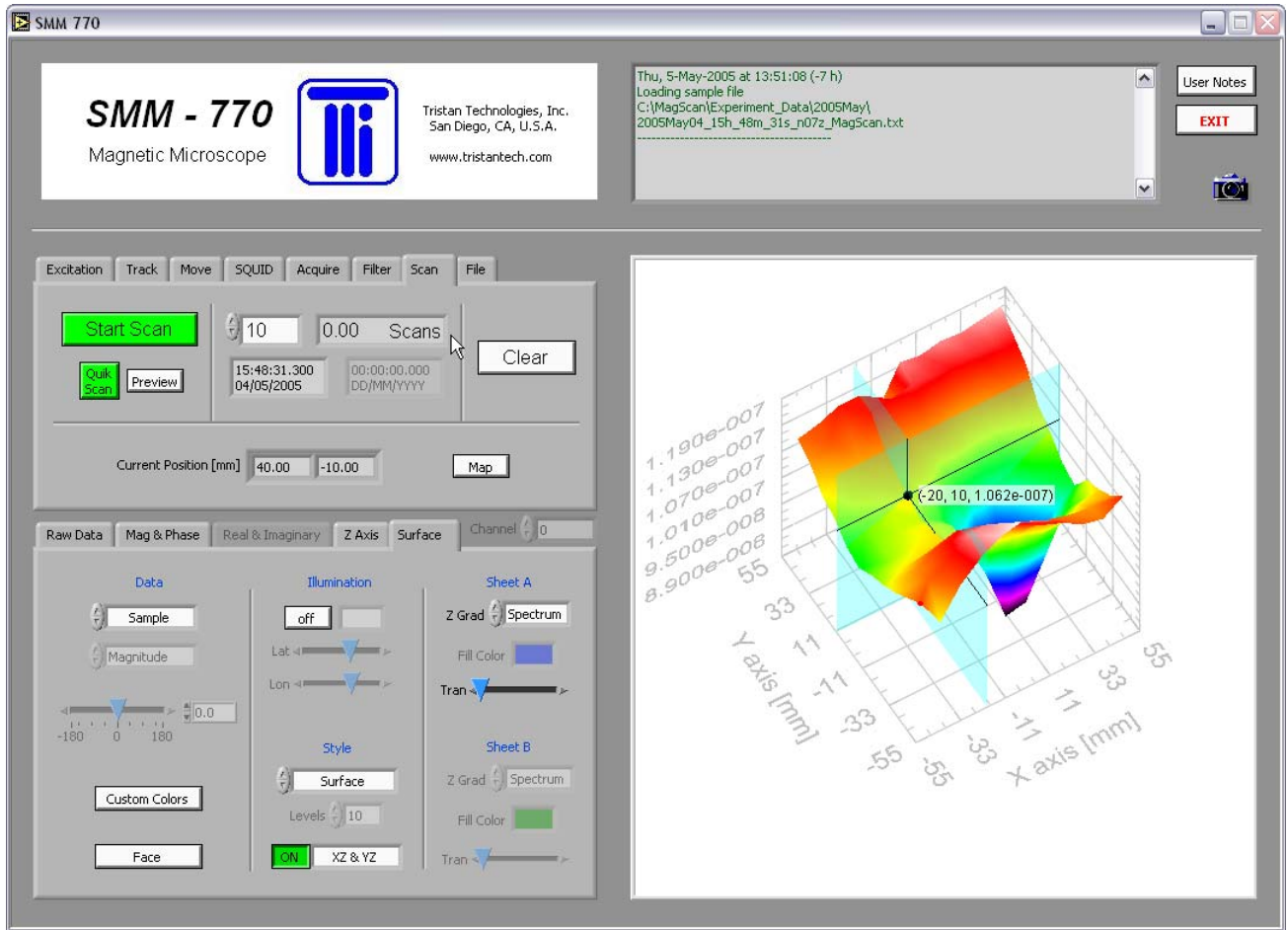
Figure 4-14:   Cursor usage in the 3D plot
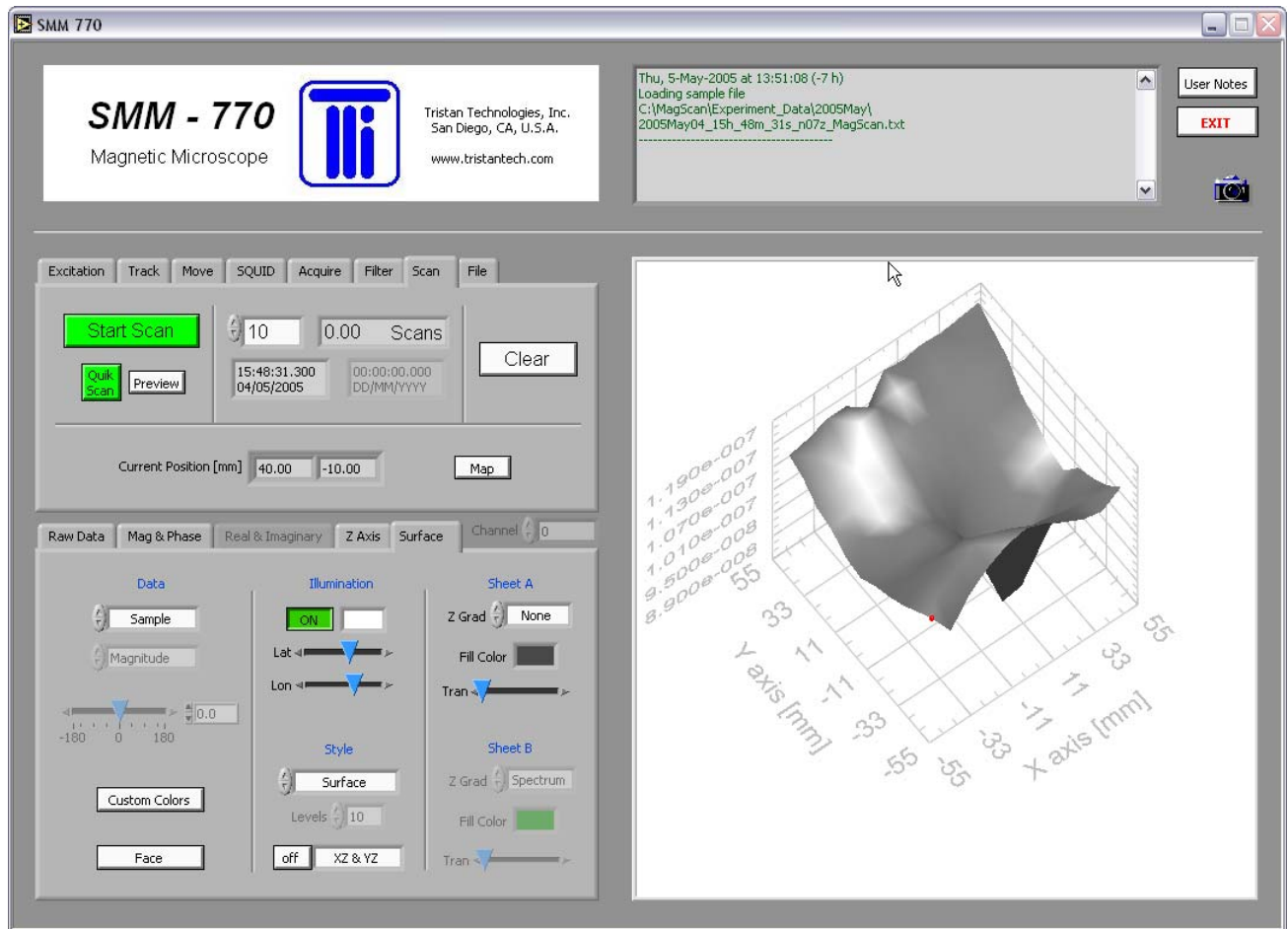
Figure 4-15   Illumination control in the 3D plot

The X and Y values from the cursor can be exported to the track parameters under the *Track* tab by pressing the small round button next to the track parameters table. This is useful for selecting a smaller scan region for more detailed study.

The *Z-axis* tab controls scaling and trimming of the Z-axis.
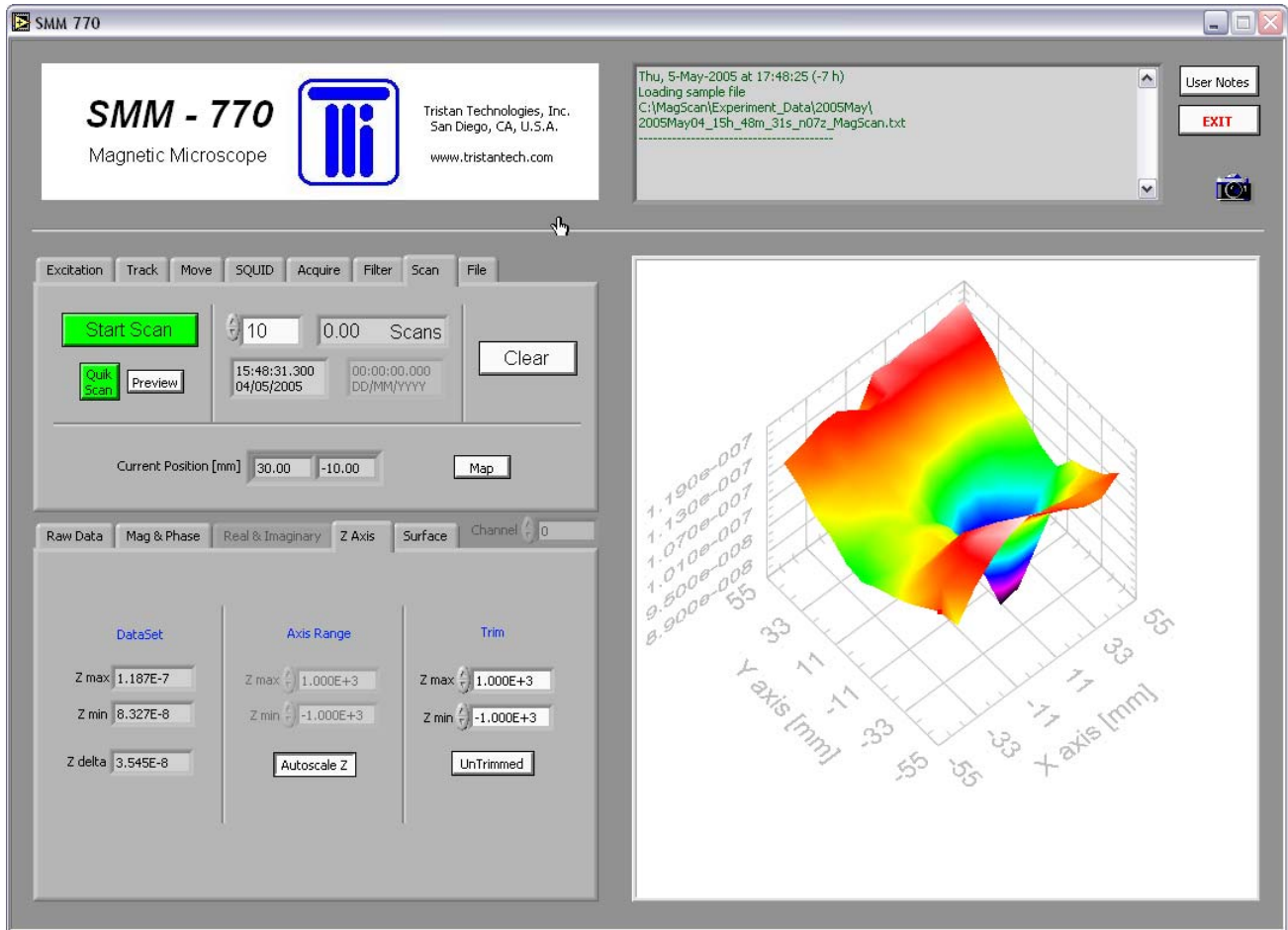
Figure 4-16:   Z-axis control

Customized color mapping of the Z-axis is available under the **Z Grad** selector under the *Surface* tab. The particular custom color map is specified from an ASCII file by the **Custom Colors** button under the *Surface* tab. These files are located under `c:\MagScan\Color_Map\*.txt`.

The difference between two scans can be plotted by using the **Sample vs Ref** selection under the *Surface* tab. However, to do this, the user must have data loaded as Sample and data loaded as Reference, using the utilities provided under the *File* tab. Only data collected during discrete scans can be subtracted, and the two files must have a matching scan track.

Pressing the **camera** button will capture an image and save it with an automatically-generated name, consisting of the date and time. It will be stored under `c:\MagScan\Experiment_Data\<YYYYMMM>\<date>_<time>_3DImage.bmp`.

4.9 OUTPUT FILE

The *File* tab controls saving and loading of the scan data.
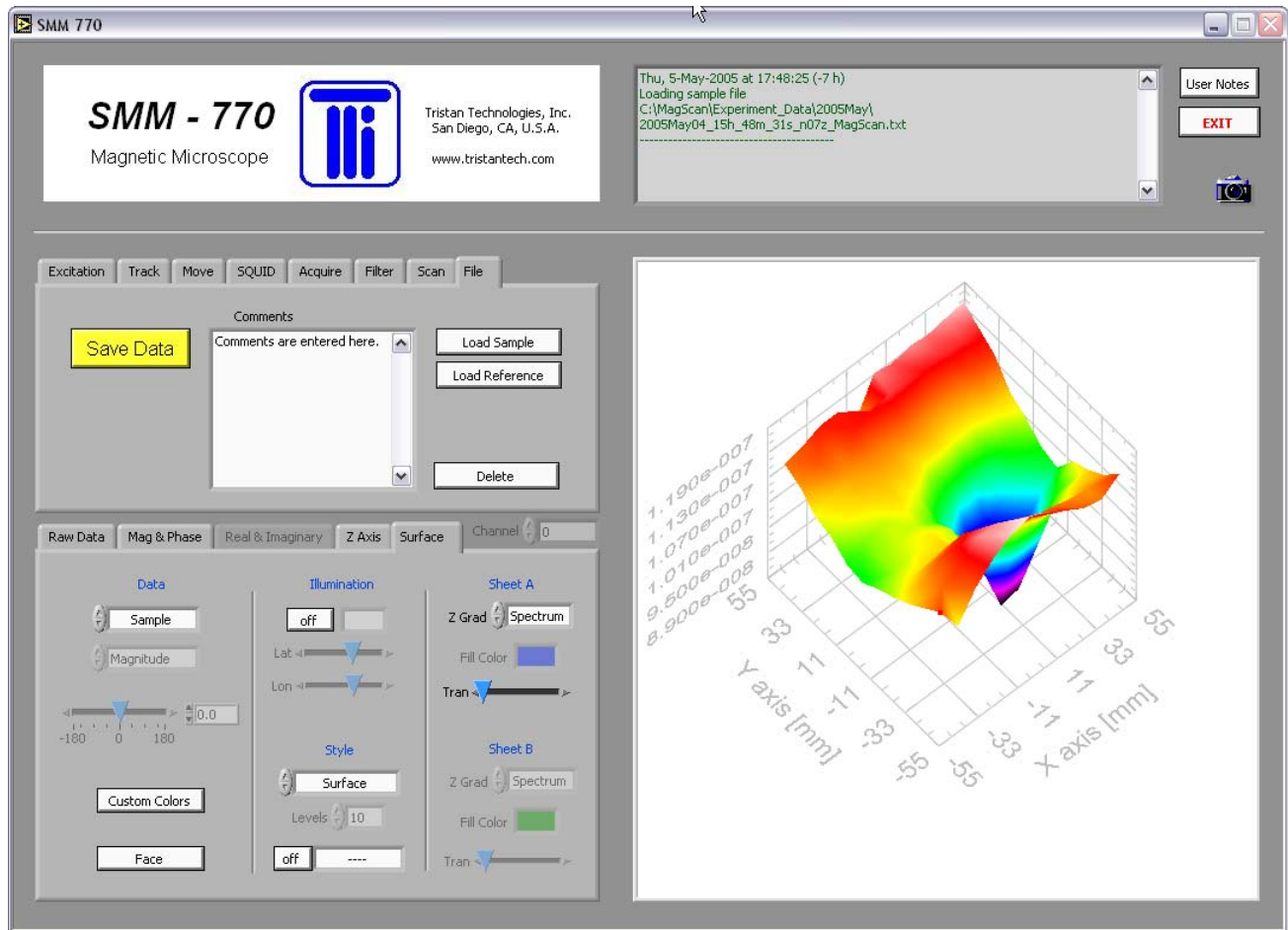
Figure 4-17:   File saving and loading

When the *Save Data* button is pressed, the sample data is stored as a simple ASCII text file, with a header that lists relevant settings, followed by the scan data in tab-delimited spreadsheet form. Data files are named automatically using the current date and time, and are placed under `c:\MagScan\Experiment_Data\<YYYYMMM>\<date>_<time>_MagScan.txt.` If the sample was scanned using the discrete SloScan, the file extension will be *.txt; if the sample was scanned using the continuous QuikScan, the file extension will be *.quk. The beginning portion of an example data file is shown below:

<start description>
The user description is entered here.
<end description>

<start miscvar>
File Format Version   1.0
Scan Start Time 3198091711.3
Scan Stop Time 3198093717.5
Total Scans   0.00
Total Samples   0
Total Channels 1
Minimum XYZ -50.00,-50.00,0.00
Maximum XYZ 50.00,50.00,0.00
Resolution XYZ 10.0000,10.0000,1.0000

Orientation   Standard
<end miscvar>

<start header>

X position [mm]	Y position [mm]	Z position [mm]	Ch1_Amplitude [T]	Ch1_Phase [deg]

<end header>

<start databody>

-50.000	-50.000	0.000	1.11680E-7	0.00000E+0
-40.000	-50.000	0.000	1.05115E-7	0.00000E+0
-30.000	-50.000	0.000	1.11305E-7	0.00000E+0
-20.000	-50.000	0.000	1.15239E-7	0.00000E+0
-10.000	-50.000	0.000	1.17729E-7	0.00000E+0
0.000	-50.000	0.000	1.18715E-7	0.00000E+0
10.000	-50.000	0.000	1.16748E-7	0.00000E+0
20.000	-50.000	0.000	1.13808E-7	0.00000E+0
30.000	-50.000	0.000	1.11195E-7	0.00000E+0
40.000	-50.000	0.000	1.10079E-7	0.00000E+0
50.000	-50.000	0.000	1.13069E-7	0.00000E+0
50.000	-40.000	0.000	1.09179E-7	0.00000E+0
40.000	-40.000	0.000	1.08981E-7	0.00000E+0
30.000	-40.000	0.000	1.09549E-7	0.00000E+0
20.000	-40.000	0.000	1.10870E-7	0.00000E+0
10.000	-40.000	0.000	1.11470E-7	0.00000E+0
0.000	-40.000	0.000	1.14418E-7	0.00000E+0
-10.000	-40.000	0.000	1.16637E-7	0.00000E+0
-20.000	-40.000	0.000	1.16594E-7	0.00000E+0
-30.000	-40.000	0.000	1.12890E-7	0.00000E+0
-40.000	-40.000	0.000	1.10677E-7	0.00000E+0
-50.000	-40.000	0.000	1.09514E-7	0.00000E+0
-50.000	-30.000	0.000	1.06294E-7	0.00000E+0
-40.000	-30.000	0.000	1.09226E-7	0.00000E+0
-30.000	-30.000	0.000	1.12193E-7	0.00000E+0
-20.000	-30.000	0.000	1.13648E-7	0.00000E+0
-10.000	-30.000	0.000	1.12666E-7	0.00000E+0

etc.

Figure 4-18   Example data file

Stored *.txt (discrete SloScan data) data files can be retrieved as either a Sample or a Reference, and displayed using the selector under the Surface tab. If the user wishes to display Sample versus Reference, the two files must have identical tracks. Stored *.quk (continuous QuikScan data) files can not be retrieved for display.

Data files can be deleted by pressing the **Delete** button. This will pop-up a panel for editing the data files, as shown below:

Scan File Listing

C:\MagScan\Experiment_Data

File path	Created
2005May04_15h_48m_31s_n07z_MagScan.txt	Wed, 4-May-2005 at 16:39:45 (-7 h)
2005Apr29_13h_44m_50s_n07z_MagScan.txt	Fri, 29-Apr-2005 at 16:00:31 (-7 h)
2005Apr29_11h_36m_46s_n07z_MagScan.txt	Fri, 29-Apr-2005 at 11:50:22 (-7 h)
2005Apr29_11h_21m_38s_n07z_MagScan.txt	Fri, 29-Apr-2005 at 11:36:36 (-7 h)
2005Apr27_12h_53m_23s_n07z_MagScan.txt	Wed, 27-Apr-2005 at 14:00:16 (-7 h)

5   total files

Delete selected files

RETURN

(use <shift> to select multiple files)

Figure 4-19:   Deletion of data files

4.10 VIDEO CAMERA

The Hitachi video camera monitors the gap between the sample and the bottom of the dewar. It is mounted behind the dewar, facing to the front, and the gap between the dewar and the sample is back-lit using the Dolan-Jenner fiber-optic illuminator.

The software for viewing the camera image is independent of the MagScan application. It is started by clicking on the Camera icon on the desktop. This will open up a front panel on the right-hand monitor that shows the live camera image.

The image can be panned and zoomed using the controls to the left of the image. Also, there are controls for drawing fixed shapes on top of the image.

Pressing the **camera** button will capture an image and save it with an automatically-generated name, consisting of the date and time. It will be stored along with the scan data files under
`c:\MagScan\Experiment_Data\<YYYYMMM>\<date>_<time>_Camera.bmp`.
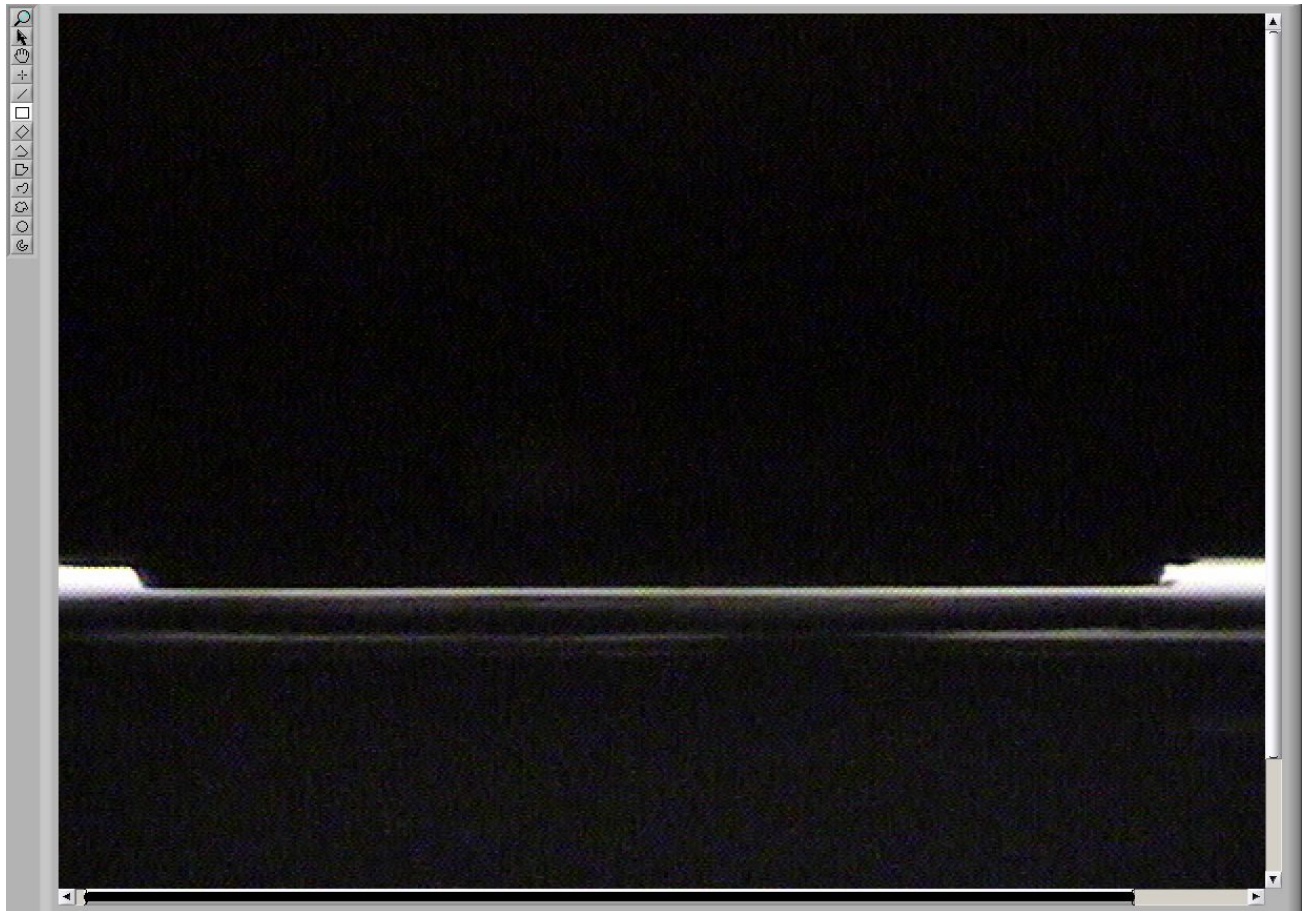
Figure 4-20   Gap between the window and sample as seen by the video camera

5. Service and Maintenance

5.1 Inspection and Cleaning

The most important feature in the care of the system is regularly filling the system with liquid Nitrogen. This must be done to keep the SQUID detection circuitry operational. In addition to this, the system must be kept magnetically clean near the sensor region. Always use gloves and special care in handling the dewar.

5.2 Cryogenic Dewar Maintenance

5.2.1 Vacuum

In normal operation the Dewar should not need pumping since the Dewar has activated charcoal getter inside on the cold surfaces. When the Dewar is warm, the static pressure at the start (with any vacuum pump removed) should be <50 micron. Upon cool down, the vacuum should quickly drop to zero (<5 microns). In the event that the Dewar vacuum must be renewed, a turbo molecular pump or liquid nitrogen trapped diffusion pump should be used to reduce the vacuum <4 x 10^{-5} Torr. Do not allow rapid gas flow in or out in order to avoid destroying the delicate superinsulation throughout the Dewar. Use a throttle valve or a short pulsing motion on the Cryolab plug valve to keep the flow rate low especially in the beginning when the bulk of the air is being removed.

5.2.2 Liquid nitrogen filling.

Liquid nitrogen may be refilled with a funnel and a small supply Dewar or Styrofoam coffee cup, or with a flexible metal hose and dip tube, which can reach near the bottom of the Dewar. The reservoir is 6" deep and the neck is 6" long, so a fill tube should be about 12"-1/4" long to reach through the Mu metal shielding port**.** Initial cool-down and filling the 2.4 liter reservoir takes about 25 minutes with a pressurized supply Dewar or 3 – 4 hours with a funnel and hand pouring. Refilling a nearly empty Dewar should take about 5 minutes with a pressurized supply Dewar and about 20 minutes with a funnel and cup. Be sure that attention is paid during and after filling so that water moisture does not accumulate on the Dewar top and drip into the neck. Before shipping the measured boil off rate (Figure 5-1) showed a 5 day interval between required refills.

WARNING

Do not allow water to drip into the neck! This will quickly seal the dewar creating a serious explosion hazard.

Remove blockages at once with a hot metal rod or compressed nitrogen flowing through a tube!

Boil 0ff SMM770#3
run#1- 5/20/05

Depth=15.3 cm   2.29 liter volume
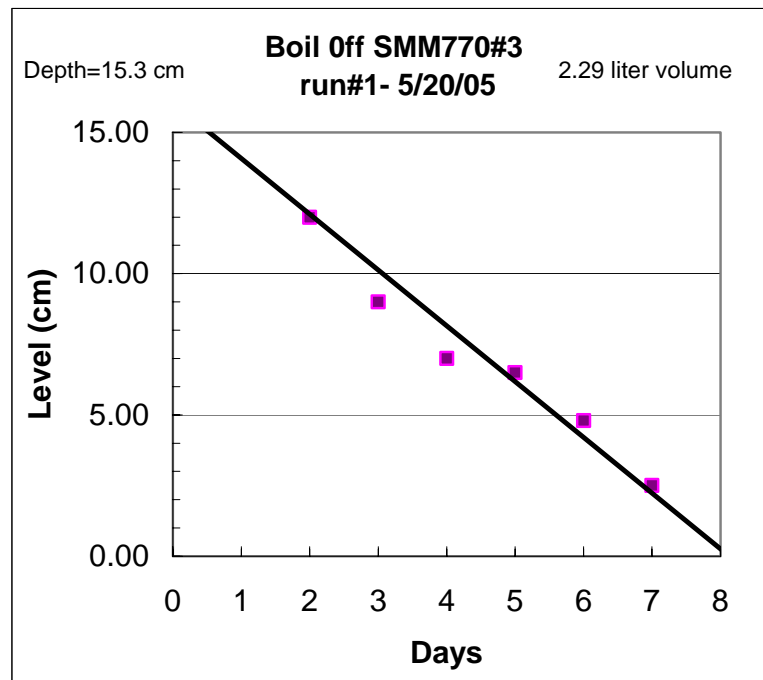
Figure 5-1   Measured boil off rate

5.2.3 Sensor Maintenance

The sensor window is .002" (51 microns) Sapphire.

WARNING

The Sapphire widow is very fragile! It must never be touched with the sample or anything else. It is not covered by any warranties.

If the window is broken and vacuum is lost while the Dewar is cold, several things will happen:

1. There will be a rapid loss of liquid nitrogen from the reservoir. **This could form a violent stream of Liquid Nitrogen, which could be hazardous. Use caution.** When the Dewar has emptied itself, and the danger of liquid nitrogen "burns " has passed, the window must be sealed and the Dewar evacuated as soon as possible.

2. To reduce the chance that the SQUID sensor itself is not damaged by moisture, temporarily seal the window with tape or other appropriate plug. Attach a vacuum pump hose to the Cryolab valve operator and open the valve with a clockwise twisting motion. Keep pumping until the Dewar is at room temperature (many hours).

3. The cold inner parts will condense moisture from the available air. This moisture, if allowed to collect, will destroy the superinsulation and the SQUID sensor itself. If the Dewar is warm when the vacuum is lost, the available moisture in air is enough to ruin the SQUID within ~20 minutes. If an emergency seal and vacuum pump cannot be applied immediately, an airtight bag with desiccant packets can be used to store the

Dewar until repairs can be made. It may be possible to save the SQUID sensor itself with quick action.

4. In any case, once the Dewar is warm, "back-fill" the Dewar with dry nitrogen and attach a solid seal (glue on a small coin), and re evacuate the Dewar for safety in handling. A new window must be installed at the factory.

5. It is also likely that the super insulation is disturbed from rapid gas (air) flow and the unit will have to be returned to the factory for service. Keep in mind that the only thing that holds the Dewar top and bottom together is the vacuum in the Dewar.

6. **Do not attempt to move the Dewar from its gantry housing until you are certain that the Dewar is holding a good vacuum.** If this is not possible, carefully wrap the Dewar end joints with strong tape and then carefully remove it from the gantry. If tape needs to be wrapped around the Dewar, the front of the gantry may be opened. Remove the laser mounted in front and remove the 6 small screws from the sides of the cover. The Dewar is held in with 3 PVC bolts. Care must be taken to disconnect all the wiring including the small connector at the base of the Dewar for the AC calibration coil. Add more tape, pack it in a **LOW g SHIPPING CONTAINER** and return it to Tristan Technology for service.

Keep alcohol and solvents off the Sensor window edges at ALL times. IT WILL DISSOLVE the adhesive causing loss of vacuum.

5.3 Gantry Maintenance

Oil and grease the x-y stages per Parker-Hanafin instructions. Do not use excessive spray oils as they make it difficult to keep the interior of the cabinet clean. Keep dust and contaminations out of the work area and keep the cabinet closed when possible. Keep external surfaces clean with household window cleaner.

Video Camera, Optics, and Fiber Optic light units should be maintained in accordance with the appropriate Hitachi, Computar, and Stocker-Yale manuals.

5.4 Vibration Isolation equipment

The Air Suspension table and Active Damping isolation units are described in the Newport Optics Manual. Special attention needs to be given for the Jun-Air compressor and air filters and regulators to maintain proper operation. Check fluid level in the compressor according to the manual.

6. Optional Equipment

6.1 Option 77P Pneumatic Vibration Isolation

An IsoStation Vibration Isolated Workstation air suspension table is used in combination with option 77V. This table is designed for high load applications and has been tested at 500 lb and is designed for >5Hz isolation.

6.2 Option 77V Active Vibration Cancellation

The SMM770, IsoStation Vibration Isolated Workstation air suspension table is equipped with an active damping system from Newport. The Optics Activator AD500, model NVX-1206-1, improves low frequency performance providing a 12db gain at 1Hz and 500 lb.
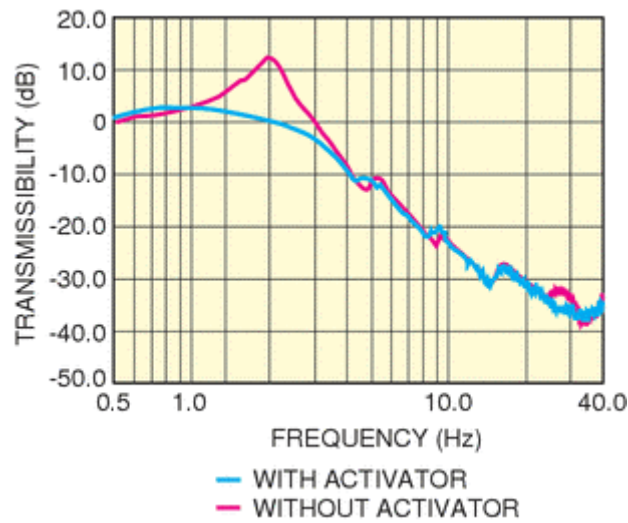
Figure 6-1   Passive Newport table vs. Newport table with the Activator installed in a horizontal configuration
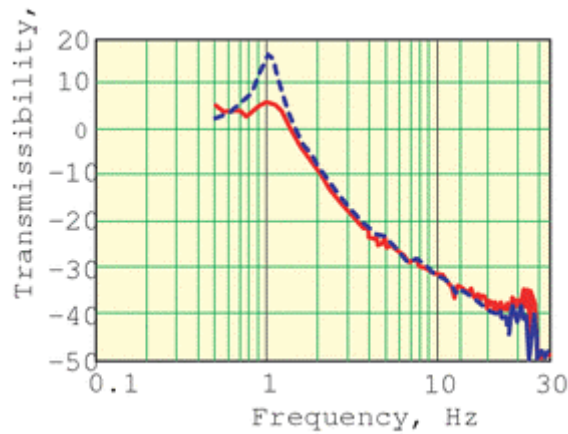
Figure 6-2   Passive Newport table vs. Newport table with activator and without activators and load of 500lbs.

6.3 Option 77T Tilt Tip Frame

¼-20 thread 3" base 15 degree plane and knob has 360 degree of marks. e.g. - one turn of knob is 17 micron at the left edge.
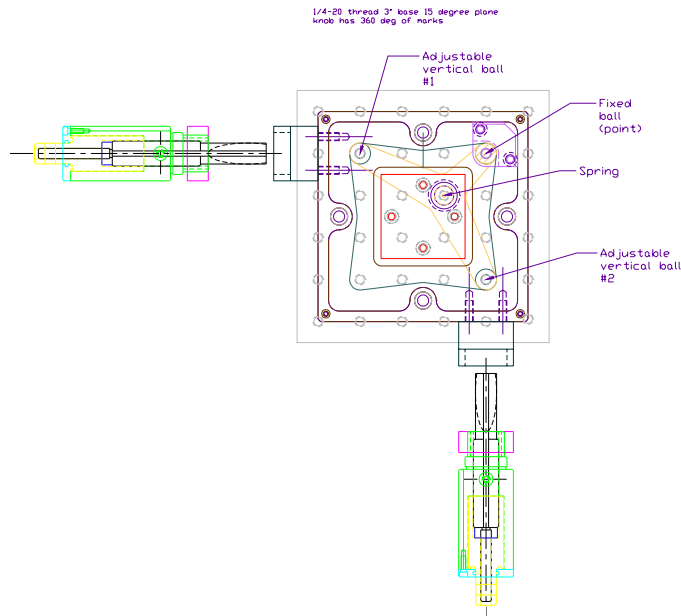
X tilt:

Full 360 deg turn of knob, across 150 mm of stage surface, yields left +17 mil, right -5 mil, which is 0.1165 deg of tilt.

Y tilt:

Full 360 deg turn of knob, across 150 mm of stage surface, yields back +17 mil, front -5 mil, which is 0.1165 deg of tilt.

A 1 deg turn of the tilt adjustment thus causes 150 mm*tan(0.1165deg/360deg) = 0.847 uM height change across the stage.

6.4 Option 77B Fixed Field Capability

The system was tested with a ring of magnets attached to the bottom of the system. The ring is shown in Figure 6-3.
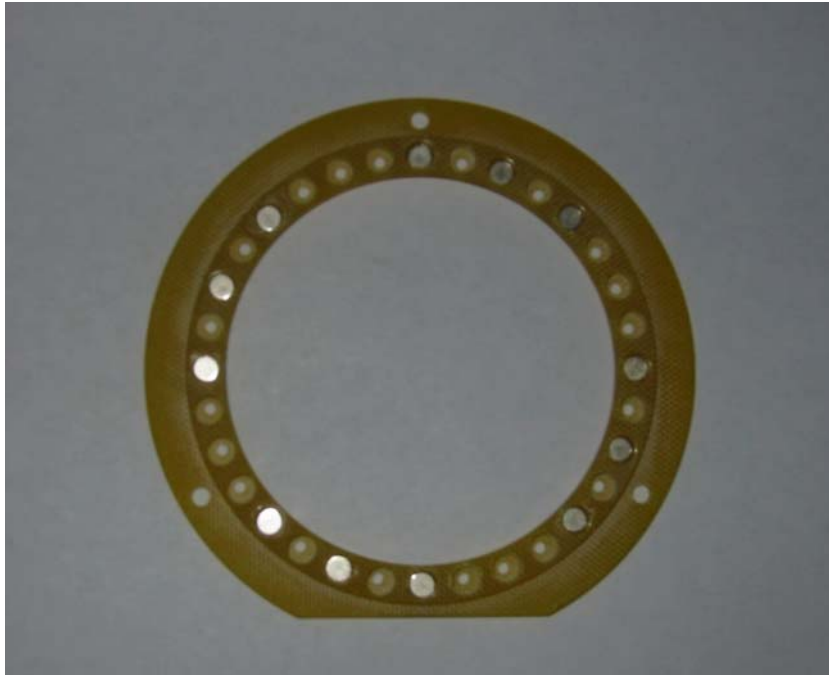
Figure 6-3   Magnet test ring (option 77B)

The field profile for the ring for an unshielded laboratory measurement utilizing a Hall probe is shown in Figure 6-4 and Figure 6-5.
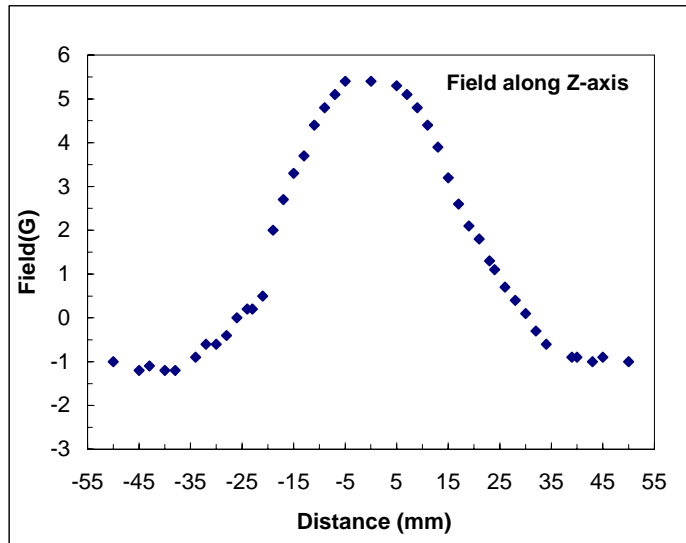
Figure 6-4   Field profile along Z axis of magnetic ring
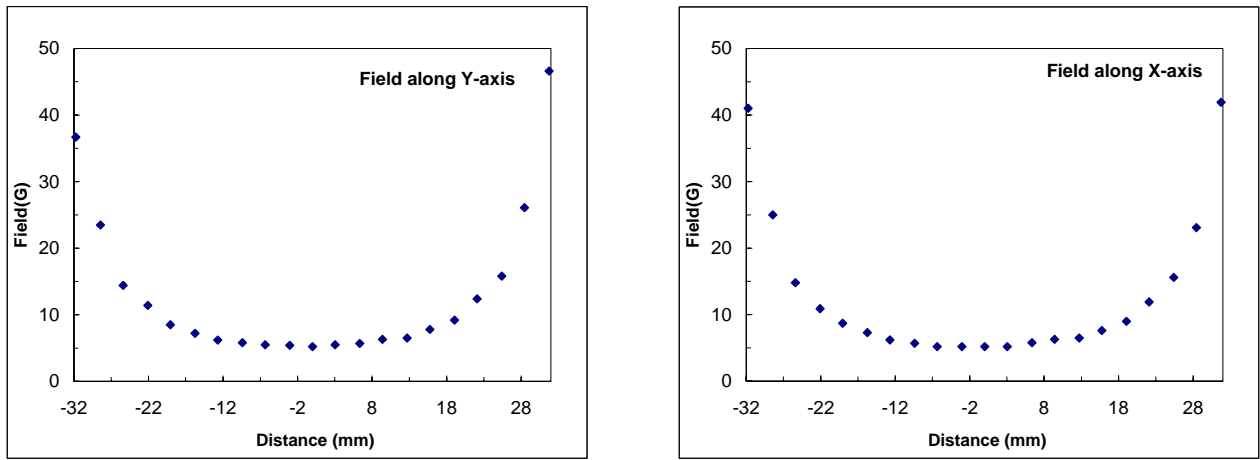
Figure 6-5   Field profile along y and x axis of magnetic ring

The system ran well with this field applied. There was very little change in the fft and the bandwidth remained >10Khz. See the Figures below:
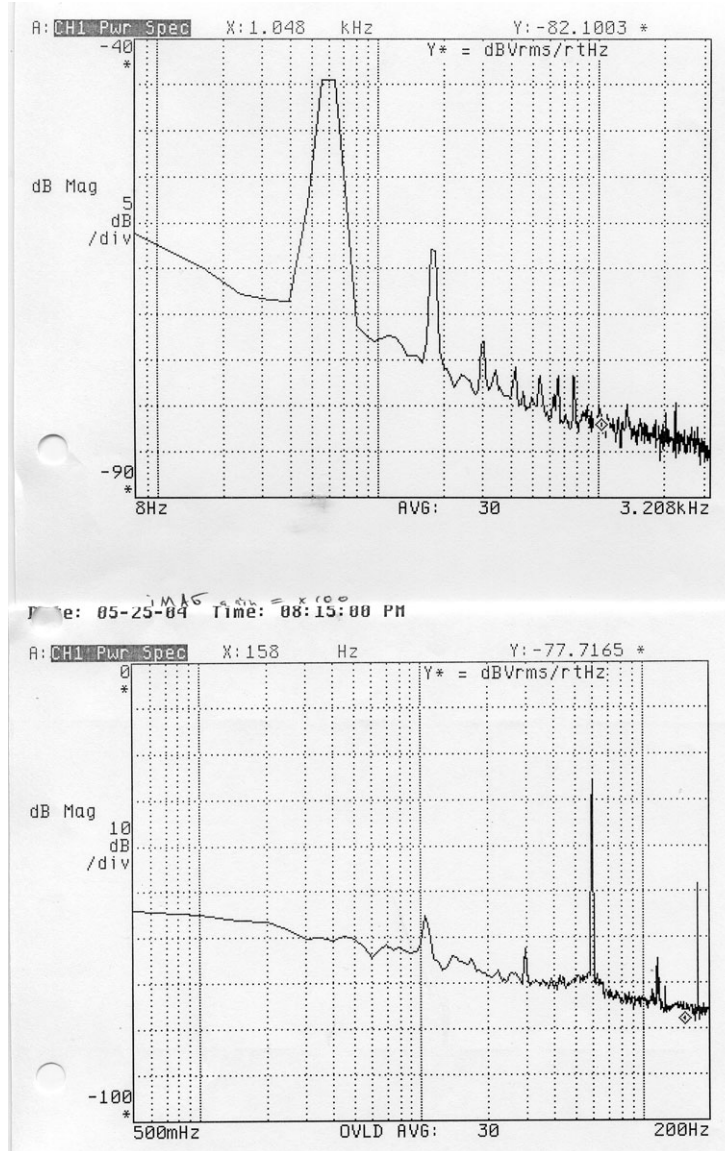
Figure 6-6:   Noise spectra of SMM-770 system with 5.5 Gauss external applied field, Gain x100
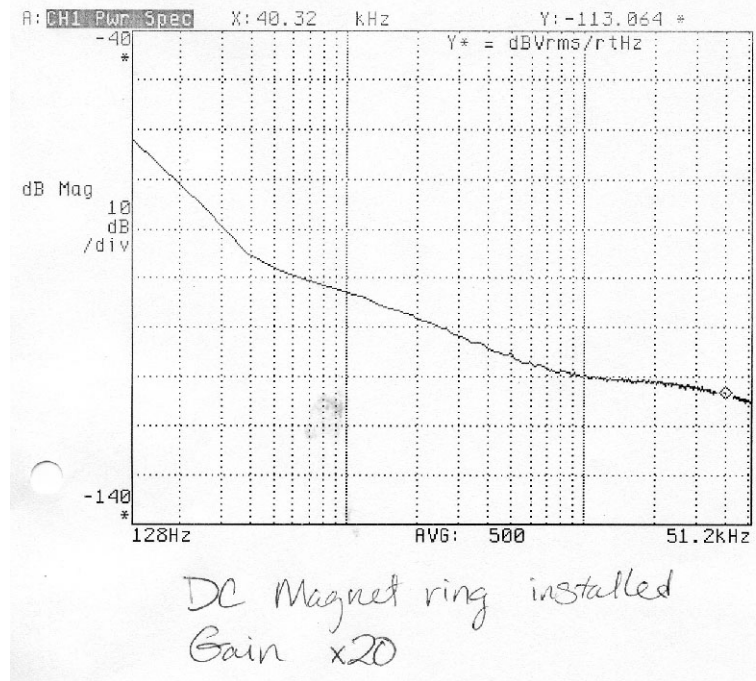
Figure 6-7:   Noise spectra of SMM-770 system with 5.5 Gauss external applied field, Gain x20

6.5 Option 77HR 12.5 Micron Step Capacity

The stage was supplied with a nominal step resolution of 1/2000 mm. The maximum recommended speed is 240 rpm, and manufacture's stated repeatability is +/- 3μm.

In additional, a vertical translator, with an associated digital micrometer, provides up to 1 inch travel length with a 1 μm repeatability. A laser ranger and associate display allows for a relative position reading within a 10 μm accuracy. The factory set calibration can be lost if the laser sensor is repositioned. The calibration procedure must be repeated following the instructions described in the Laser Ranger; Banner LG10A65Piand the Readout; Red Lion PAXP-1/8 manuals.

6.6 Option MS-770 Two Layer Mu Metal Magnetic Shield

The optional MS770 two layer mu-metal shield provides attenuation of external magnetic fields. Figure 6-8 gives nominal dimensions (in inches).
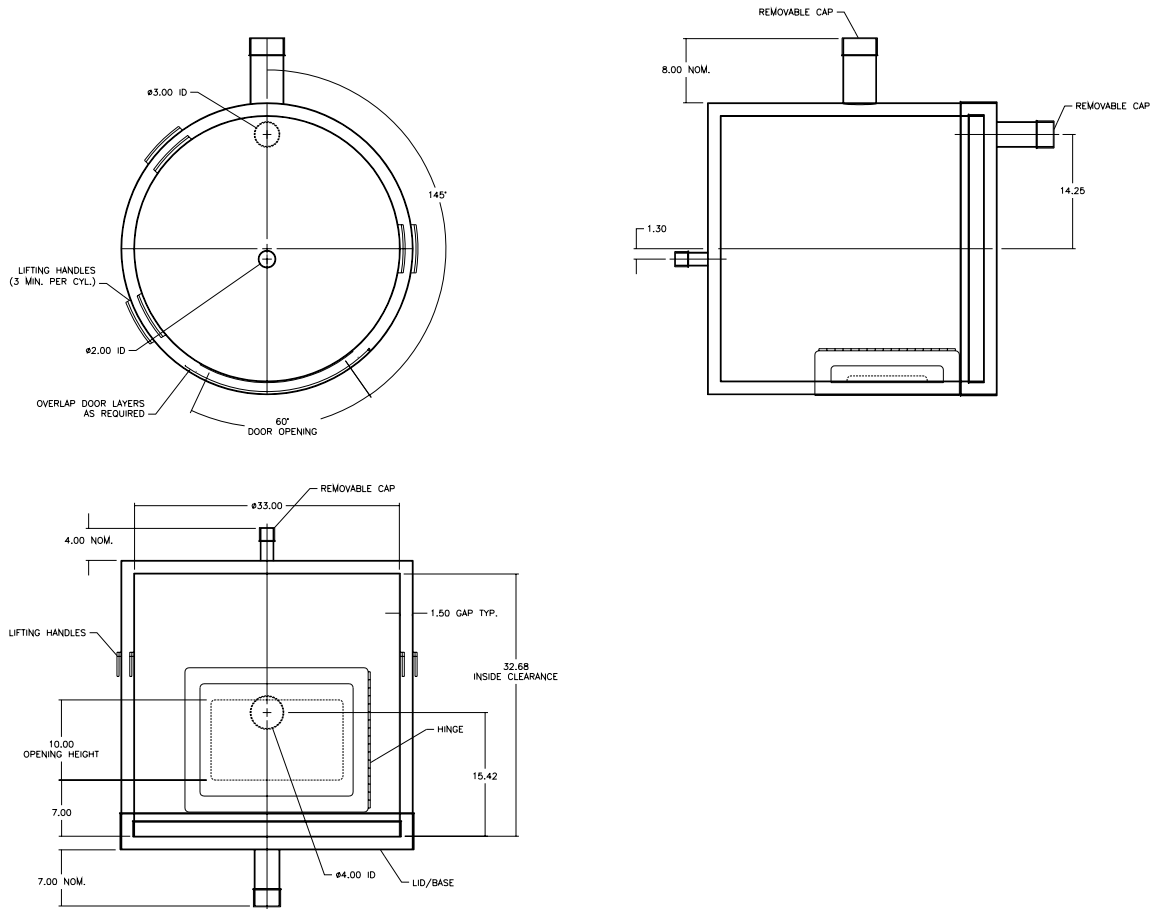
Figure 6-8:   MS770 mu-metal shield engineering drawings.

The Mu metal shield is sensitive to mechanical shock and bending. The high nickel content material is very soft and must be handled with care. This is especially true when lifting of and removing the top cylinder for instrument setup and service. Normal sample set-up access is available through the inspection door and LN_2 can be added to the dewar through the access port in the top. Lifting of the top cylinder should be avoided as much as much as possible to reduce risk of damage.

The door should be opened and closed slowly to avoid bending the hinges of damaging the twist lock fasteners.

One note about opening and closing the dual-layer door. When closing the door, grasp the black door handle and unlatch the bottom latch first.this helps take the weight of the doors off the hinge. When opening the latches, OK to start at the top while supporting the door by grasping the door handle

In the event miss-handling or accident causes the interior magnetic shielding is degraded, contact Tristan for instructions on degaussing the shield.

Shielding Tested –May 2005

50Hz testing with APS 520A Fluxgate Magnetometer and SR770 Spectrum Analyzer.

50Hz Transverse (at the door): 1587:1 (64 dB).

50Hz Axial: 2857:1 (69 dB).

Also DC with MEDA FM300 in vertical axis: At center of shield, 689:1 (56 dB).

6.6.1 Instrument specifications

1. sensor located midway up shield and 4" from centerline (towards front).

2. microscope magnetic sensitivity = 10 pT/rtHz

6.6.2 Shield Inside dimensions:

1. 33.0" diam +/- 1/4" (fits over oddly shaped footprint to be provided)

2. 32.1" inside height +/- 1/4" (1/4" clearance on instrument top).

3 "lid on bottom" geometry so that heavy and delicate microscope is undisturbed once set up.

6.6.3 Access holes:

1. **front door**: 1/4 circumference x 12" - 14" high, with top of opening 16" from base (inside dims). hinges on right side at ~ "4:00 o'clock" (door is not centered). This is the primary access for sample set up and change and has easy finger operation closing fasteners.

2. **top port**: LN2 funnel access: 1" id, in line with dewar top (1.3" from centerline of 33" can, towards the front "6:00 o'clock, for weekly access.

3. **bottom port**: positioned at ~ "10:45 o'clock": 3" Id big enough for 64 pin d-connector and the AC and DC power and all the separate signal cables, and fiber optic light source; provided with a cap with slot and clearance for the cable bundle. One time set up only.

4. **Rear port**: 5" id x 6" length, center is 15" from lower edge and at "12:00 o'clock”: access for video camera and adjustments; cap with 1/2" diam cable feedthrough access (these cables could also be lead through the #3 port as well, if it is a shielding compromise.

Figure 6-9   Option MS-770 two layer mu metal shield

7. Appendices

7.1 Thermometry and Cooldown

Table 4   Pt thermometer calibration

Cryocon Model 62 Calibration for SMM 770 Naples						
Voltage Bias	Channel	Room Temperature (K)	Liquid Nitrogen (K)	Liquid Nitrogen (Ω)	Sensor	Installed Location
10μV	A	293.883	77.46 (+/- 0.005)	19.79 (+/− 0.005)	Pt100/385	Wire Bundle base
10μV	B	293.874	77.51 (+/- 0.03)	19.81 (+/− 0.02)	Pt100/385	Probe Tip
33μV	A		77.406 (+/- 0.001)	19.773 (+/− 0.002)	Pt100/385	Wire Bundle base
33μV	B		77.42 (+/- 0.01)	19.78 (+/− 0.005)	Pt100/385	Probe Tip
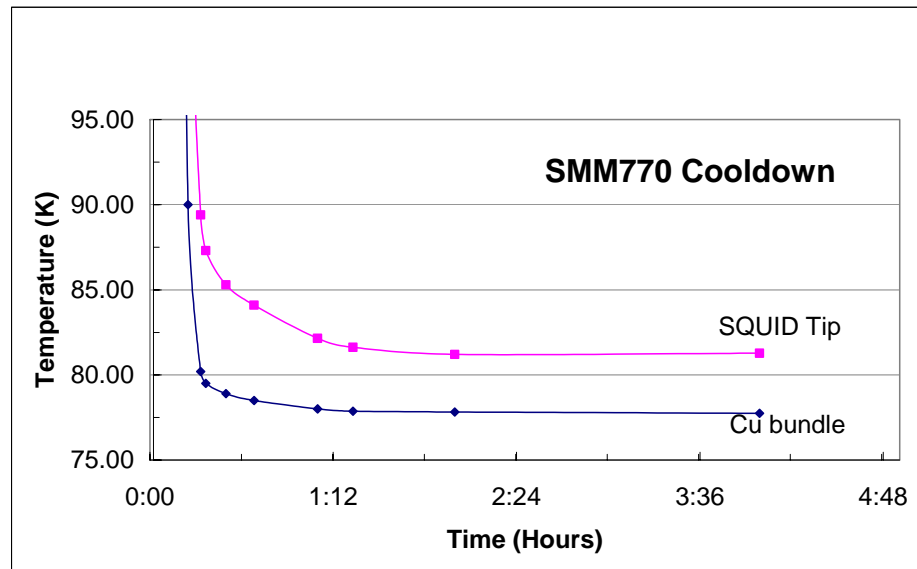
Figure 7-1   Elapsed time for SQUID tip coldwon to operating temperatures

7.2 Calculating B-fields

This section is for assistance in calculating various magnetic fields for different geometries. Units are cgs.

7.2.1 Dipole:

Field from a Short Solonoid

for r >> a,
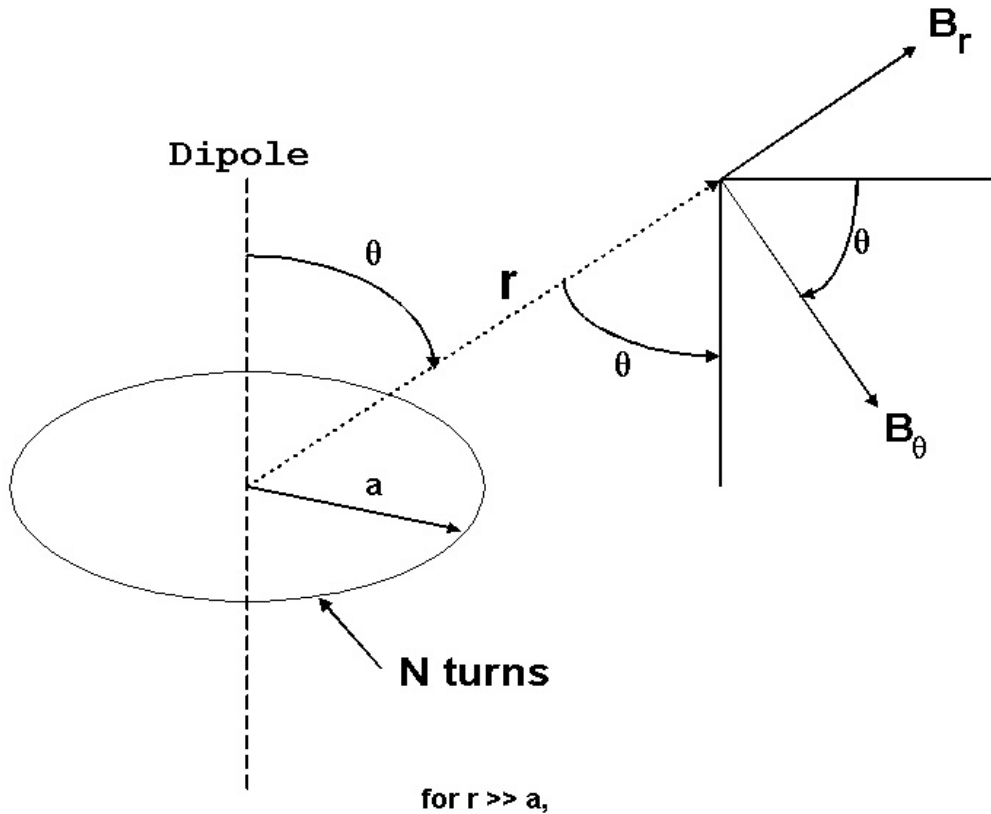
$B_r = 2B_0 \cos\theta$ (note that for $\theta = 0$, this is true even if r is not >> a, but $r \sim^{-2}(r^2+a^2)^{1/2}$

$B_\theta = B_0 \sin\theta$

where

$B_0 = \pi N/10 \text{turns}(I/1\text{amp})(a/1\text{cm})^2(1\text{cm}/r)^3 \text{ gauss}$

and,
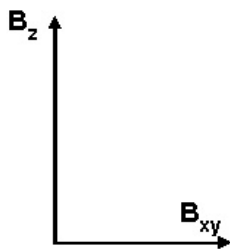
$B_z = B_r\cos\theta - B_\theta\sin\theta = B_0(3\cos^2\theta - 1)$

$B_{xy} = B_r\sin\theta + B_\theta\cos\theta = B_0 (2\cos\theta\sin\theta + \sin^2\theta\cos\theta) = 3B_0\cos\theta\sin\theta$

7.2.2 Field at center of loop:

Field at Center of Circular Loop

N turns

d
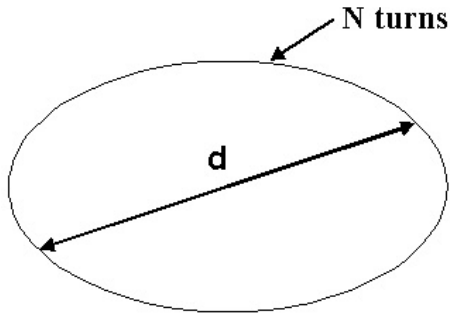
$$B = N\mu_0 I/d$$
$$\mu_0 = 4\pi \times 10^{-7} H/m = 4\pi/10 \ Gauss/Amp$$

7.2.3 Field above straight wire.

B field of Straight Wire

B

α   β

d
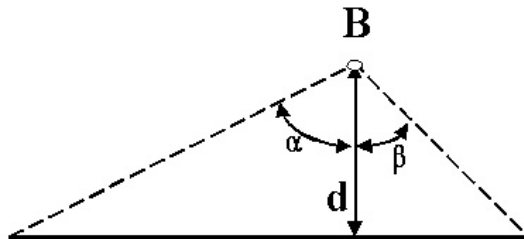
$$B = (\mu_0 I/4\pi d)(\sin\alpha + \sin\beta)$$

7.2.4 Meander Field

Field in nT is given by:

$$B_m = \left| \left[\frac{-x-\frac{d}{2}}{h^2+(x+\frac{d}{2})} + \frac{x-\frac{d}{2}}{h^2+(x-\frac{d}{2})^2} \right] 2x10^4 \, x(I) \right.$$

Where:

d = Separation between wires (0.00762 cm)

x = horizontal distance with respect to meander center (cm)

h = Vertical liftoff from meander center to SQUID (cm)

I = Current flowing the meander given in amperes

7.3 Wiring and Hardware Configuration

MOTORS

Parker ZETA57-51-MO, phase coils wired in series

Motor red wire (A+) (phase A) --> Pin 1 of Stepper Motors terminal block of MID-7602
Motor yellow wire (phase A center tap 1) --> Motor blue wire (phase A center tap 2)
Motor black wire (A-) (phase A inverse) --> Pin 2 of Stepper Motors terminal block of MID-7602
Motor bare wire (case ground) --> Pin 3 of Stepper Motors terminal block of MID-7602
Motor white wire (B+) (phase B) --> Pin 4 of Stepper Motors terminal block of MID-7602
Motor orange wire (phase B center tap 1) --> Motor brown wire (phase B center tap 2)
Motor green wire (B-) (phase B inverse) --> Pin 5 of Stepper Motors terminal block of MID-7602
Axis 1 = X Axis (left-right)
Axis 2 = Y axis (forward-back)

LIMIT SWITCHES

Limit switch yellow wire (CCW limit NO) --> Pin 1 of Limits terminal block of MID-7602
Limit switch green wire (home NO) --> Pin 2 of Limits terminal block of MID-7602
Limit switch white wire (CW limit NO) --> Pin 3 of Limits terminal block of MID-7602
Limit switch black wire (dc ground) --> Pin 6 of Limits terminal block of MID-7602
Limit switch red wire (+5V dc) --> Pin 7 of Encoders terminal block of MID-7602

DIP SWITCHES

NI-MID-7602 Axis Configuration on front panel, behind cover plate

0111001100, 0111001100
(if pin 5 = 1, there is an occasional humming sound from Axis 1 stepper)

ANALOG DATA

iMAG: channel 1 -> BNC-2090: ACH0 / ACH8 (mode DIFF)

On back of BNC-2090, switch set to MIO-16

7.3.1 Ini file description

[Comm]
FLL_RS232_Resource=ASRL1::INSTR
　　If RS-232 communication is used for the iMAG unit, this specifies the RS-232 port to use.
　　The available ports are listed under NI-MAX.

FLL_GPIB_Resource=15

If GPIB communication is used for the iMAG unit, this specifies the GPIB port to use. This number must match the iMAG unit setting.

FLL_Comm_Type=GPIB
    This specifies the type of iMAG unit communication to use. Either "GPIB" or "RS232".

[Motion]

MotorEnable=TRUE
    Enables or disables movement of the stage. Either "TRUE" or "FALSE".

MotorConv_(usteps/mm)=-2000.0,2000.0,2000.0
    Linear scaling of the stage motion for the X, Y, and Z axes.

MotorSet_(usteps/rev)=2000,2000,2000
    Rotational scaling of the stage motion for the X, Y, and Z axes.

MotorVelocity_(RPM)=240.0
    Stage motor velocity, same for all three axes.

MotorAccel_(RPS/s)=20.0
    Stage motor acceleration, same for all three axes.

HomePosition_(mm)=0,0,-75
    Offset of stage home position for the X, Y, and Z axes.

InitPos_(mm)=0.0,0.0,-75.0
    Initial position of stage after homing for the X, Y, and Z axes.

PosLimit_(mm)=77,77,38
    Maximum movement allowed by software for the stage for the X, Y,and Z axes.

NegLimit_(mm)=-77,-77,-75
    Minimum movement allowed by software for the stage for the X, Y,and Z axes.

Track_Min_(mm)=-50,-50,0
    Default track minimum for X, Y, and Z axes.

Track_Max_(mm)=50,50,0
    Default track maximum for X, Y, and Z axes.

Track_Res_(mm)=10,10,1
    Default track step size for X, Y, and Z axes.

Z_Active=FALSE
    Specifies whether there is a motor for control of the Z axis. Either "TRUE" or "FALSE".

Scan_Count_(N)=10

Default number of discrete SloScans to perform.

QuikScan_Speed=30
   Default interval (ms) between points for a continuous QuikScan.

QuikScan_InterpolationFactor=100
   Default number of points to interpolate when generating a set of points for a QuikScan.

QuikScan_SmoothingFactor=50
   Default smoothing of QuikScan points, to avoid sharp turns during a serpentine track.

QuikScan_AccelDecelPoints=32
   Default duration of acceleration/deceleration of a continuous QuikScan.

QuikScan_AccelDecelCurve=0.4
   Default magnitude of acceleration/deceleration of a continuous QuikScan.

[Excitation]

AO_Port=Dev1/ao0
   Specifies port to be used for output of an excitation signal. The available ports are listed under NI-MAX.

Channel=1
   Specifies the channel number to assign to the excitation channel. This number must be NumSQUIDs <= n <= (NumChans-1), and it must be after the

Calibration_(T/V)=8.47e-8
   Specifies the calibration of the excitation coil. If = 0, then the coil parameters listed below are used to calculate an approximate calibration.

Frequency_(Hz)=15.00
   Default frequency of the excitation signal. Allowed values are in the range 0 to 1000 Hz.

Amplitude_(T)=1e-9
   Default amplitude of the excitation signal.

Samples_Per_Buffer_(N)=250
   Points in the excitation buffer.

Cycles_Per_Buffer_(N)=5
   Periodic cycles in the excitation buffer.

Offset_(V)=0.00
   Default amplitude of the excitation signal. Allowed values are in the range -10 to 10 V.

Type=SineWave

Default type of the excitation signal. Either "SineWave", "TriangleWave", "SquareWave", or "SawtoothWave".

Coil_Diameter_(m)=0.1
Diameter of the excitation coil.

Coil_Turns_(N)=1
Turns of the excitation coil.

Coil_Resistor_(ohms)=66800
Resistance in series with the excitation coil.

Active=FALSE
Default enabling/disabling of excitation signal. Either "TRUE" or "FALSE".

Enabled=FALSE
Specifies whether or not the excitation hardware exists. Either "TRUE" or "FALSE".

[DAQ]

AI_Port=Dev1/ai0
Specifies port(s) to be used for all analog input(s), such as SQUID, excitation sensing, and misc. sensing. The available ports are listed under NI-MAX. For example, ten ports would be specified as "Dev1/ai0:9"

NumChans=1
Specifies the number of channels specified under "AI_Port". For example, if AI_Port=Dev1/ai0:9, then NumChans=10.

NumSQUIDs=1
Specifies the number of SQUID channels. This number must be <= NumChans. For multi-channel systems, SQUIDs are always the first channels, followed by other channels such as excitation sensing.

Xcoords_(mm)=0
X coordinate frame of the SQUID array. For example, a set of nine SQUIDs could be "-3,0,3,-3,0,3,-3,0,3".

Ycoords_(mm)=0
X coordinate frame of the SQUID array. For example, a set of nine SQUIDs could be "2,3,4,-1,0,1,-4,-3,-2".

Coil_Calibration_(T/V)=2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5
Calibration of the SQUID array for gains of x1 thru x500. Calibrations for differet gains are delimited by commas, and sets for each channel are delimited by semicolons. For example, a set of nine SQUIDs could have
"2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;

2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;
2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;
2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;
2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;
2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;
2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;
2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;
2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5, 2.45e-5;"

Measure_Time_(s)=1.0
   Duration over which to measure SQUID signal. This data block is then used to calculate DC offset, AC amplitude, and AC phase relative the the excitation sensing.

Settle_Time_(s)=0.100
   Duration to wait after a discrete SloScan stage movement, and before acquisition of a block of data for analysis.

Sample_Rate_(Hz)=1000
   Data acquisition rate. Allowed values are in the range of 10 to 50000 Hz.

HighPassFilter=DC
   Default iMAG high-pass filtering. Either "DC" or "0.3Hz".

LowPassFilter=off
   Default iMAG low-pass filtering. Either "off", "5Hz", "500Hz", or "5kHz".

Gain=x1
   Default iMAG gain. Either "x1", "x2", "x5", "x10", "x20", "x50", "x100", "x200", or "x500".

Offset=0
   Default iMAG offset. Integer in the range of 0 to 100.

Slew=normal
   Default iMAG slew. Either "normal" or "slow".

[Filter]

Active=FALSE
   Default enable/disable of the software filtering. Either "TRUE" or "FALSE".

Topology=IIR_Butterworth
   Default software filter topology. Either "IIR_Butterworth", "IIR_Chebyshev", "IIR_InverseChebyshev", "IIR_Elliptic", "IIR_Bessel", or "FIR_Window".

Type=Lowpass
   Default software filter type. Either "Lowpass", "Highpass", "Bandpass", or "Bandstop".

FIR_Window=None

Default software filter FIR windowing. Either "None", "Hanning", "Hamming", "Triangular", "Blackman", "ExactBlackman", "BlackmanHarris", "KaiserBessel", or "FlatTop"

Hi_Cutoff_(Hz)=37
    Default software filter high-frequency cutoff.

Lo_Cutoff_(Hz)=25
    Default software filter low-frequency cutoff.

PB_Ripple_(dB)=1
    Default software filter pass-band ripple.

SB_Attenuation_(dB)=90
    Default software filter side-band attenuation.

IIR_Order=3
    Default software filter IIR order. Allowed range is 0 to 3.

FIR_Taps=10
    Default software filter FIR taps. Allowed range is 0 to 100.

Zero_Phase=FALSE
    Default software filter zero-phase enable/disable. Either "TRUE" or "FALSE".

[Display]

Amp_Units=Pk-Pk
    Either "Pk-Pk" or "RMS".

Angle_Units=Degrees
    Either "Degrees" or "Radians".

FFT_Averaging=None
    Either "None", "Vector", "RMS", or "PeakHold".

FFT_Weighting=Exponential
    Either "Linear" or "Exponential".

FFT_AvgNum=10
    Number of running averages for the FFT display.

FFT_Window=None
    Either "None", "Hanning", "Hamming", "BlackmanHarris", "ExactBlackman", "Blackman", "FlatTop", "4TermBHarris", "7TermBHarris", or "LowSidelobe".

Type=Sample
    Default 3D display type. Either "Sample", Reference", or "SampleVsReference".

Mode=Magnitude
>   Default 3D display mode. Either "Magnitude", "Phase", "Mag&Phase", "Real", "Imaginary", "Real&Imag", "Arbitrary", "Arb+90deg", or "Arb&Arb+90deg".

Arb_Angle_(deg)=0
>   Default 3D display arbitrary angle.

Trim_Z_Max_(T)=1000
>   Default Z-axis trim maximum.

Trim_Z_Min_(T)=-1000
>   Default Z-axis trim minimum.

Trim_Active=FALSE
>   Default Z-axis trim enable/disable. Either "TRUE" or "FALSE".

Illumination_Active=FALSE
>   Default 3D display illumination enable/disble. Eithe "TRUE" or "FALSE".

Illumination_Color=16777215
>   Default 3D display illumination color.

Illumination_Latitude=45
>   Default 3D display illumination latitude.

Illumination_Longitude=45
>   Default 3D display illumination longitude.

Transparency_A=0
>   Default 3D display transparency for Sheet A.

Transparency_B=0
>   Default 3D display transparency for Sheet B.

Photo=BMP
>   File format for screen captures. Either "JPG", "PNG", or "BMP".

[Misc]

Code=39
>   Reserved

Language=English.txt
>   Reserved

7.4 Background subtraction

The following two figures show the capability of scan subtraction. The first Figure shows a background scan in an unshielded environment. The second Figure shows the result of subtracting two consecutive background scans.
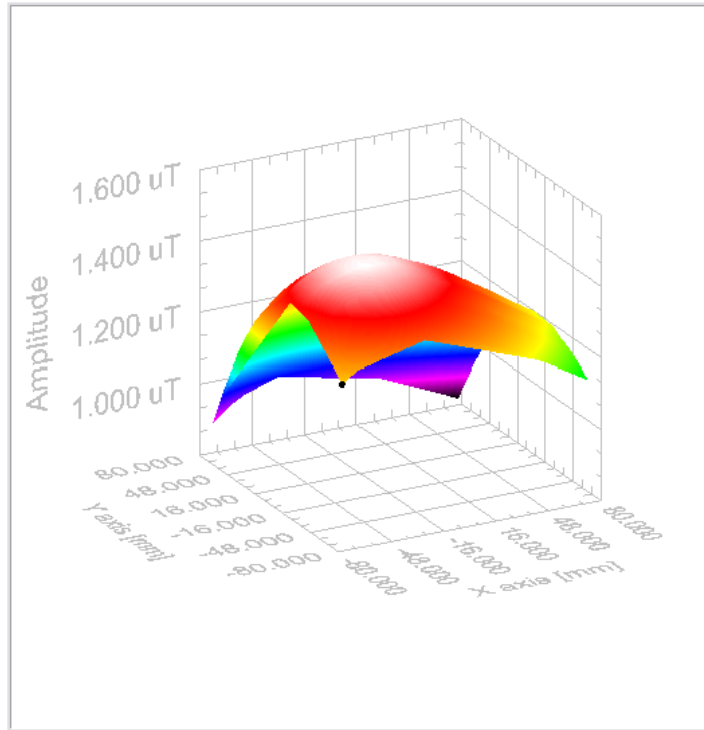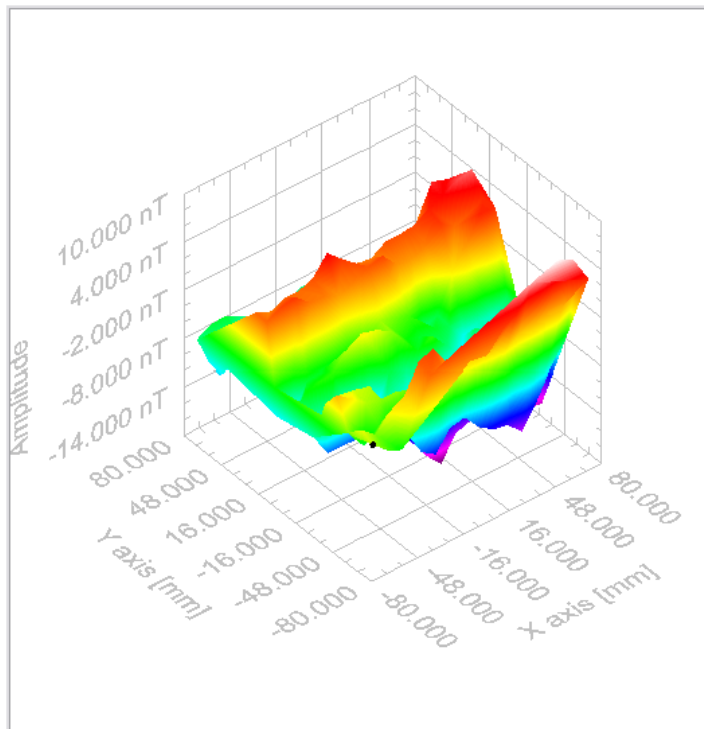

Figure 7-2   Unsubtracted background

Figure 7-3   Subtracted background

7.5 Stage calibration/test

X axis:

Minimum travel distance = -77 mm	13 May 05	CGA
Maximum travel distance = +77 mm	13 May 05	CGA
Backlash = 8 microns	27 May 05	CGA
Movement resolution < 10 micron	27 May 05	CGA
Nominal 500 micron movement = 19.5 mil	27 May 05	CGA
Nominal 50 mm movement = 50.02 mm	27 May 05	CGA

Y axis:

Minimum travel distance = -77 mm	13 May 05	CGA
Maximum travel distance = +77 mm	13 May 05	CGA
Backlash = 8 microns	27 May 05	CGA
Movement resolution < 10 micron	27 May 05	CGA
Nominal 500 micron movement = 19.5 mil	27 May 05	CGA
Nominal 50 mm movement = 49.99 mm	27 May 05	CGA

Z axis:

Minimum travel distance = 0 mm	27 May 05	CGA
Maximum travel distance = 25.4 mm	27 May 05	CGA
Backlash < 2 microns	27 May 05	CGA

X tilt:

Full 360 deg turn of knob, across 150 mm left +17 mil, right -5 mil, 0.1165 deg	27 May 05	CGA

Y tilt:

Full 360 deg turn of knob, across 150 mm back +17 mil, front -5 mil, 0.1165 deg	27 May 05	CGA

8. HTS SQUID Handling Cautions

SQUIDS ARE ELECTROSTATIC SENSITIVE AND HYDROSCOPIC –Use Care.

- When turning the system off remove power cable from the FLL and then turn off AC power.

- Do NOT touch the bare SQUID room temperature connections when the SQUID is cold or disconnect the powered FLL amplifier at the dewar connector (DO remove the fiberoptic power cable first from the FLL- if necessary and then the cryocable connector). Static discharge through the leads will destroy the squid junctions when @77K.

- When testing the SQUID/cables at room temperature limit the current by using a manual (1K or higher) range on a low current DVM.

- Store the device in a dry atmosphere when not in use. Do NOT let sit in a sealed dewar with water condensed on the bottom.

- Do not heat the sensor without additional limits on the heater current if the sensor is mounted in vacuum.

- Do not heat the SQUID when sitting at room temperature in a dewar.

Avoid static electricity by handling the sensors - SQUID is an electrostatic sensitive device; Do NOT touch the bare SQUID room temperature connections when the SQUID is cold or disconnect the powered FLL amplifier at the dewar connector (**DO remove the fiber-optic power cable from the FLL first and then the cryo-cable connecto**r). Static discharge through the leads will destroy the squid junctions when @77K.

When testing the SQUID/cables at room temperature limit the current by using a manual (1K or higher) range on a low current DVM.

Do not heat the sensor without additional limits on the heater current if the sensor is mounted in vacuum.

To make measurements in a magnetically unshielded environment use grounded tight RF-shielding.

1. Cool down the SQUID for 5 minutes with TRISTAN electronics not connected.

   (**LONGER IS ALWAYS BETTER IF TIME ALOTS**)

2. Switch on the TRISTAN electronics; go to SETUP; go to MANUAL TUNING; ENTER;

3. Reduce BIAS, MOD, SKEW - all to 0 %.

4. Leave the electronics warming at least for about 10 minutes.

5. Connect 10-pos. LEMO connectors between the electronics and the cryocable.

6. Connect the 5-pos. LEMO plug to the FLL last, all other connectors should be connected.

7. Press TUNE.

8. Heat the SQUID for about 2 sec in low field area.

9. Leave SQUID cooling down after heating for about 2 min. Then run TUNE again.

When turning the system off DO remove the fiber-optic power cable first from the FLL and then turn off AC power.

Store the device in a dry atmosphere when not in use. Do NOT let sit in a sealed dewar with water condensed on the bottom.

Do not heat the SQUID when sitting at room temperature in a dewar

Handling for Shipping and/or Storing at Room Temperature

- SQUIDs are electro-static discharge (ESD) sensitive devices. Always store them in appropriate ESD safe packaging.

- Use appropriate static sensitive handling equipment such as ESD mats and wrist straps when handling and connecting High Temperature SQUIDs.

- Connect the shunting plug at the top connector when the SQUID is not in use for extended periods and always for shipment.

Be sure to install shunting plugs on the connector of the SQUID when it is not in use for extended periods or during shipping.

- Store the SQUID sensor in a moisture free environment by using desiccant in conjunction with a closed container. **This is especially important in humid or damp environments.** Typically desiccant (Silica Gel) appears blue when active and red or pink when saturated with moisture.
- When warming the SQUID sensor, immediately place the SQUID sensor in a plastic bag when it is removed from the cryogen to minimize the condensation of water vapor on the cold surfaces. After the SQUID sensor reaches room temperature, dry the body of the SQUID sensor / Probe (observing ESD precautions) and then store with desiccant.

- When testing the SQUID cables at room temperature limit the current by using a manual range on a low current digital multi-meter. Do not use the auto-range function of the digital multi-meter. Select the "K Ω range".

- Do not heat the SQUID (using HEAT button on the Tristan model iMC-303 SQUID Control Electronics or equivalent heating circuit) at when the SQUID sensor is at room temperature.

- Ship the SQUID sensor with the shunting plug attached and in a closed container with desiccant inside.

- **NEVER** allow the SQUID to sit in a sealed dewar with water condensed on the bottom.